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## **The Husbandry of Hatchling to Yearling Kemp's Ridley Sea Turtles (Lepidochelys Kempi)**

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## FOREWORD

Head starting is one of a number of potentially effective conservation and management tools that may help prevent extinction of the seriously endangered Kemp's ridley sea turtle, Lepidochelys kempi. However, head starting's utility and effectiveness in conservation and management are unproven (Klima and McVey, 1981). Though seven year-classes (1978-1984) of Kemp's ridley have been head started at the National Marine Fisheries Service, Southeast Fisheries Center's Galveston Laboratory, and 9,258 survivors have been tagged and released into the Gulf of Mexico, none of these animals has returned to nest so far as is known. Therefore, head starting is still experimental.

Head starting is expensive (exceeding \$150 per animal per year) and labor-intensive, requiring considerable resources of personnel, facilities, and supplies. However, these costs are not high compared to those of maintaining and breeding other large tetrapods in captivity; e.g., for medical research, to prevent extinction of endangered species, or for public display.

Because each species of sea turtle has somewhat different and unique traits that adapt it for survival, each also has somewhat different requirements for captive rearing. As an example, Kemp's ridley is aggressive, so its young are reared in isolation to prevent them from injuring each other.

It is encouraging that two five-year-old, head started Kemp's ridleys, held in captivity through their entire life, laid eggs at the Cayman Turtle Farm [1983] Ltd. on Grand Cayman Island in May 1984 (Wood and Wood 1984). In spring 1985 there were additional reports of reproductive behavior in the Kemp's ridleys at the farm (James Wood, personal communication). These events document the earliest age for nesting in the species. Though none of the hatchlings survived, such early nesting is an encouraging initial step toward captive breeding as a "safety-net" for the species. It also adds impetus to the Kemp's ridley head start research project by giving an indication that head started, tagged ridleys released into the Gulf of Mexico may approach maturity more rapidly than was originally thought possible.

In this paper on the husbandry of Kemp's ridley sea turtle, the authors describe the facilities, equipment, methods and techniques adapted and developed by the Galveston Laboratory. These methods not only have provided the animals tagged and released into the gulf, but also 210 yearlings that have been distributed among eight organizations for extended head starting or captive breeding. These organizations are now maintaining 75 survivors. Some of the survivors may be released at a later date, and others retained in captivity as a potential brood stock. Plans are to add up to 50 more ridleys of the 1984 year-class to this captive stock. Of the turtles that were tagged and released, 380 have been recovered to date (Sharon Manzella, personal communication, June 1985), providing information on tag retention, survival, growth and dispersion within the Gulf of Mexico, along the eastern coast of the United States, and in European Atlantic waters.

According to Dr. Edward F. Klima, Galveston Laboratory Director, Southeast Fisheries Center, Galveston, Texas, those who use this paper should be cautioned that experimental head starting requires a long-term commitment (10-15 years). Successful rearing of sea turtles in captivity requires considerable dedication among the personnel involved and substantial financial resources as well as an appropriate infrastructure, both within and outside any organization or agency that chooses to investigate head starting of sea turtles as a potential management tool. Ultimate success of head starting can be achieved only with the nesting of head started turtles and survival of their young. That will require their survival, growth, maturation, and successful migration to a nesting beach as well as successful mating, nesting and hatching. Many questions remain concerning captive rearing. For example, most of the head started turtles have been released as yearlings, but younger or older animals might be better for release.

This paper contains information supplementing currently available literature on the rearing and maintenance of young sea turtles in captivity. On the short-term, much has been learned by successful head starting of Kemp's ridley, but greater public awareness and support are required to generate the additional resources needed to continue

and to expand the project as well as test its success as one means of saving the Kemp's ridley from extinction.

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## INTRODUCTION

The Kemp's ridley sea turtle Lepidochelys kempi, has been on the endangered species list since the passage of the U.S. Endangered Species Act in 1973. The Kemp's ridley nests each year on a beach bordering the Gulf of Mexico near the village of Rancho Nuevo, in the State of Tamaulipas, Mexico (Chávez et al. 1968). In 1947, Hildebrand (1963) estimated that 40,000 female Kemp's ridleys were nesting on this beach, but by 1982 the number had declined to about 1,500 (Marquez et al. 1981). The primary cause of the population decline is thought to be overexploitation of the adults and eggs by man. Presently, the nesting beach near Rancho Nuevo is protected during the nesting season from April to July by Mexican Marines and personnel of the Instituto Nacional de la Pesca (INP) of Mexico, with assistance from the U.S. Fish and Wildlife Service (FWS) and others. This protection has reduced the poaching by man (Marquez et al. 1982).

Since 1978, the National Marine Fisheries Service (NMFS), Southeast Fisheries Center (SEFC), Galveston Laboratory has participated in the international program to save the endangered Kemp's ridley sea turtle from extinction (Klima and McVey 1981). The program is a joint conservation effort among the INP, the FWS, the NMFS, the National Park Service (NPS), and the Texas Parks and Wildlife Department (TPWD), with assistance from the U.S. Navy and Coast Guard, and the Florida Department of Natural Resources (FDNR).

The goal of this program is to increase the Kemp's ridley population. The approach includes protection of nesting turtles and their eggs on the beach at Rancho Nuevo, prohibitions on the capture, possession and sale of sea turtles in the United States, use of the trawling efficiency device (TED) to allow escapement of turtles captured incidentally in shrimp trawls, and head starting Kemp's ridleys in captivity during their first year of life. Head started Kemp's ridleys, "imprinted" as hatchlings at Padre Island, have been tagged and released in hopes of establishing a new nesting colony at the



Padre Island National Seashore, near Corpus Christi, Texas. Others have been "imprinted" at Rancho Nuevo to supplement that breeding colony.

Head starting involves the husbandry of young turtles during the critical first year of life as well as the tagging and release of survivors. In addition, the program has provided answers to many questions concerning biology, physiology, and pathology of this endangered species, as well as the fate of cultured turtles at sea.

The sea turtle head start research project at the NMFS Galveston Laboratory falls within the Protected Species Program administered by the NMFS SEFC, in Miami, Florida. Project objectives are to:

- (1) provide husbandry to captive Kemp's ridley sea turtles to increase their survival and optimize their growth during the critical first year of life;
- (2) tag healthy survivors of each year-class of head started Kemp's ridley sea turtles and release them into their natural environment;
- (3) monitor growth, survival and migration of head started Kemp's ridleys based on reported recoveries;
- (4) establish a new nesting colony of Kemp's ridleys at the Padre Island National Seashore; and
- (5) develop and expand a captive brood stock.

Criteria for gauging success in the project are:

- (1) survival and growth of head started animals in captivity during the first year of life;

- (2) nesting of head started animals on any beach;
- (3) nesting of head started animals on beaches to which they were exposed as eggs and hatchlings; and
- (4) copulation and nesting within the captive brood stock of head started animals.

In theory, imprinting (species-specific, rapid learning during a critical time of early life in which social attachment and identification are established) occurs during incubation and hatching of the eggs in beach sand and during exposure of hatchlings to the adjacent surf, thus acting as a memory code to guide adult turtles back to their natal beach. At Rancho Nuevo each season, a portion of the eggs are collected in plastic bags as they are laid so they do not touch the local beach sand. These eggs are placed in polystyrene foam boxes containing beach sand from Padre Island and are flown to the Padre Island National Seashore where they are placed in a hatchery and allowed to continue incubation. NPS biologists carefully monitor environmental conditions in the boxes during the incubation that normally takes between 43 and 53 days (Robert King, NPS, personal communication, July 1984). Hatchlings are taken to the beach and allowed to crawl across the sand to the surf to enhance their opportunity for imprinting. The hatchlings are recovered from the surf, placed in boxes lined with polyurethane foam cushions and flown by U.S. Navy aircraft to Galveston. In the past, some eggs also have been collected, incubated, and hatched in Rancho Nuevo beach sand and the hatchlings reared at Galveston.

Head starting, as practiced by the NMFS Galveston Laboratory, is thought to give the young Kemp's ridleys an advantage in survival and growth over their natural counterparts (Klima and McVey 1981;



Fontaine, Leong and Caillouet 1983; Caillouet 1984; Caillouet et al.<sup>1/</sup>; Fontaine et al.<sup>2/</sup>). We believe that natural survival of this turtle during its critical first year of life is less than 1%. Survival during head starting over a 7-12 month period in captivity has ranged from 65% to 95% (Table 1). Of the total of 10,376 hatchlings received alive from year-classes 1978-1983, 8,241 (79%) were reared, tagged and released. Of those released, 378 have been recovered. Growth for each year-class, as expressed by plots of arithmetic average weight versus time, is presented in Fig. 1. Caillouet et al.<sup>1/</sup> examined growth and survival of the 1978-1983 year-classes of head started Kemp's ridleys in detail.

Most head started and tagged turtles were released into the Gulf of Mexico, but some were held back as a potential brood stock (Table 1). Twenty-nine of the 1978 year-class, and 50 of the 1979 year-class were transferred to the Miami Seaquarium (8 survivors of the 1978 and 1 survivor of the 1979 year-classes), Miami, Florida and ten of the 1978 year-class to Sea-Arama Marineworld (8 survivors), Galveston, Texas. Of the 100 animals from the 1979 year-class that were shipped to Cancun, Mexico, 96 survivors were transferred to the Cayman Turtle Farm [1983], Ltd. (34 survivors), on Grand Cayman Island. To each of the following public marine aquaria (Table 2), 5 turtles of the 1982 year-class were transferred: Clearwater Marine Science Center,

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<sup>1/</sup>Caillouet, C. W., Jr., D. B. Koi, C. T. Fontaine, T. D. Williams, W. J. Browning and R. M. Harris. Growth and survival of Kemp's ridley sea turtle, Lepidochelys kempi, in captivity. Manuscript submitted to the editor of Chelonian Documentation Center, Bulletin.

<sup>2/</sup>Fontaine, C. T., R. M. Harris, W. J. Browning, and T. D. Williams. Observations on the growth and distribution of head started/tagged/released Kemp's ridley sea turtles (Lepidochelys kempi) from year-classes 1978-1983. Manuscript in preparation. NMFS SEFC Galveston Laboratory, Galveston, Texas.

Clearwater, Florida; Gulfarium, Ft. Walton Beach, Florida; Key West Municipal Aquarium, Key West, Florida; Turtle Kraals, Key West, Florida (these were transferred to Theater of the Sea, Islamorada, Florida on 16 April 1985); and Marine Life, Inc., Gulfport, Mississippi. All except one turtle that died at Gulfarium remain alive. Purposes of holding these turtles captive beyond one year were (1) to extend the head starting period for 2-4 additional years thus providing larger and older animals for release, and (2) to provide a stock of potential breeders in captivity as a "safety net" for the species (Caillouet 1984). Some of these captive turtles have been tagged with the "living tag." The living tag refers to the process by which a piece of the lighter colored plastron is grafted into the darker tissue of the carapace. If the tissue graft is successful, a very distinguishable white mark is made in the darker carapace. Others have been tagged with binary-coded, internal tags. All were tagged with monel flipper tags. Thus, these turtles provide an opportunity for determining tag retention and recognition over time. Other head started Kemp's ridleys having abnormalities, serious injuries, or incurable diseases were either transferred to universities for research purposes or humanely disposed of as allowed under FWS permit (Table 1).

The Kemp's ridley sea turtle head start research project in Galveston has been conducted under permits issued by the INP, the FWS, and the TPWD (see ACKNOWLEDGMENTS). Wastewater discharge effluent quality has been regulated by permit no. 02299 from the Texas Department of Water Resources (TDWR).

#### PURPOSE

The purpose of this paper is to document the general husbandry, including equipment, methods, and techniques, used to rear Kemp's ridley sea turtles from hatchlings to yearlings. The facilities and methods have evolved since 1978 based on the cumulative research,

experiences and efforts of those engaged in rearing Kemp's ridleys over the life of the project. This paper primarily presents those procedures used during the rearing of the 1982-1983 year-classes. General recommendations for the care and rearing of captive sea turtles have been presented by Bjorndal and Balazs (1983).

#### SEA TURTLE HEAD START RESEARCH FACILITIES

Location - The sea turtle head start research facilities are located at the NMFS SEFC Galveston Laboratory, 4700 Avenue U, Galveston, Texas (Fig. 2).

Seawater - Seawater is pumped from the Gulf of Mexico through submerged well-points located approximately 200 m from the surfline of the beach. The seawater is stored initially at the Galveston Laboratory in underground concrete sump pits (113,460 liter; 30,000 gal) and then pumped to above-ground, redwood storage tanks (94,550 liter; 25,000 gal). Seawater is then delivered from the redwood tanks to the head start facilities into six, insulated, fiberglass reservoirs (Fig. 3). The four smaller reservoirs have a capacity of 28,390 liter (7,500 gal) each, while the two larger ones have a capacity of 37,850 liter (10,000 gal) each. The two larger reservoirs are for secondary use to provide back-up supplies of seawater, while the four smaller reservoirs provide the primary or immediate supply of seawater. During the months of cold weather, seawater in the four smaller reservoirs is heated to 28°C by thermostatically-controlled immersion heaters (Table 3). When needed, seawater can either be drained from any of six reservoirs by gravity-flow or pumped by two centrifugal pumps (Table 3).

Facilities - The sea turtle head start research facilities consist of two, aluminum-framed, quonset huts (X. S. Smith, Inc.<sup>3/</sup>) covered by inflated double-layers of white polyethylene sheathing. Originally, one quonset hut, 74.4 m (244 ft) long by 9.2 m (30 ft) wide, was installed. After hurricane Alicia, which inflicted severe damage to this structure in August 1983 (Fig. 4), two separate quonset huts were constructed, each 29.3 m (96 ft) long by 9.2 m (30 ft) wide (Fig. 5). This separation into two parts and the reduction in size of the structure were done to simplify replacement of tops and to reduce the cost of heating during the winter. The two quonset huts are heated by two, natural gas-fired, forced-air heaters.

The long axis of the quonset huts is situated on an east-west orientation so that the prevailing southeasterly winds will provide cross-ventilation and cooling during the summer. The sides of the quonset huts are equipped with lateral "vent-rails" located 1.2 m (4 ft) above ground level; panels of polyethylene sheathing attached to the rails can be removed during summer months for ventilation. The space between the inflated, double-layered, polyethylene tops is maintained by small fans at approximately 20.3 cm (8 in). This "air-space" between the layers provides additional insulation. The tops normally last 12-18 months, but are replaced annually following the hurricane season and before winter.

Equipment - The 15 fiberglass raceways (numbered 1-15 from east and west) and 120 hemispherical basins used to rear turtles in the facility were manufactured by Red Ewald, Inc. The raceways are rectangular (Fig. 6), measuring 6.1 m (20 ft) long x 1.8 m (6 ft) wide x 0.6 m (2 ft) deep, and are normally filled to a depth of 30.5 cm (12 in), providing a seawater volume of 3,141 liter (830 gal). The raceways are fitted on the north end with a 10.2 cm (4 inch, inside diameter) standpipe drain (Fig. 7) and a 3.8 cm (1.5 inch, inside

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<sup>3/</sup>Throughout this paper, the mention of trade names or commercial products does not imply endorsement or recommendation for use.

diameter) drain pipe on the bottom at the same end as the standpipe. The raceways are drained by rotating the 10.2 cm standpipe downward and removing a rubber stopper from the 3.8 cm bottom drain.

Hatchling Kemp's ridley sea turtles are aggressive and will attack and injure each other (Klima and McVey 1981; Bjorndal and Balazs 1983); consequently, they cannot be held together in an open tank. Therefore, each raceway is fitted with 18 5.1 cm (2 in) x 5.1 cm wooden poles, placed across the width of the raceways (Fig. 8), from which six plastic buckets, 28 cm (11 in) deep by 22 cm (9 in, inside diameter), are suspended with 10-gauge galvanized wire. Eighteen such rows (lettered A-R from south to north) and six columns (numbered 1-6 from east to west) of buckets provide a total of 108 buckets per raceway. The bottom of each bucket was drilled with 12 holes, each 2.5 cm (1 in) in diameter, to allow water exchange and liberation of turtle excrement and waste food. Each turtle remains in its assigned bucket throughout the head start process, unless it dies or becomes ill (in which case it is transferred to sick bay, treated, and returned to the same bucket if it is cured). The raceway and bucket locations provide codes used as identifiers for individual turtles throughout head starting.

Turtles that out grow their buckets are transferred to fiberglass basins (Fig. 9). The hemispherical basins are 61 cm (24 in) in diameter and 25 cm (10 in) deep and are normally filled with 26.5 liter (7 gal) of seawater. The seawater is exchanged and the basins cleaned on a daily basis.

The sick bay (Fig. 10), where sick turtles are isolated for observation and treatment, contains 86 fiberglass basins similar to those described in the previous paragraph. When in use, the basins are drained, scrubbed with a heavy brush, disinfected with Chlorox, rinsed, and filled with clean seawater on a daily basis.



Wastewater Treatment - When in use, the raceways are scrubbed once each week, five (raceways 1-5) on Monday, five (raceways 6-10) on Wednesday, and five (raceways 11-15) on Friday. Cleaning of a raceway involves draining the water, washing down the turtles, buckets, and raceway with freshwater (tapwater), rinsing out the raceway with freshwater, scrubbing the inside walls of the raceway with heavy-duty brushes to remove attached algae, rinsing the tank once again with freshwater, and refilling the tank with clean seawater. The fresh tapwater is not heated in the winter time prior to use. Apparently this has caused no ill effects to the turtles.

The drained seawater and water from scrubblings and rinsings are collected in a concrete trough (Fig. 7) that empties into a 0.9 m (3 ft) by 1.8 m (6 ft) fiberglass sump pit located outside of the turtle facility. Two solid-waste sump pumps (Table 2) transfer this water into two cylindrical, fiberglass, digestion tanks, 1.5 m (5 ft) high by 6.1 m (20 ft) in diameter (Fig. 11), each holding a volume of 44,568 liter (11,775 gal).

The treatment of the wastewater is based on aerobic digestion of proteinacious material and was developed with the assistance of Dr. Dennis Clifford, Environmental Research Department, University of Houston, Houston, Texas. This process reduces the biochemical oxygen demand (BOD) of the wastewater. In general, the organic wastes that produce BOD are decomposed by bacteria, in the presence of nutrients and dissolved oxygen, into carbon dioxide and water, with the production of more bacteria. Marine algae grow in this nutrient-rich medium. The bacteria that die and the algae also contribute to the BOD. The liquid fraction of this decomposition and some suspended solids are discharged after treatment with hydrogen peroxide (Fig. 12). The solids that precipitate are retained as activated sludge to re-seed the process.

An array of polyvinyl chloride (PVC) pipes 3.8 cm (1.5 in) drilled at 2.54 cm (1 in) intervals with 0.4 cm (0.016 in) holes was placed on the bottom of each digestion tank and used to keep the wastewater



vigorously aerated. Air is supplied to the pipes by two Cyclonaire blowers (Table 3). After aeration of the wastewater for 20 hr, the blowers are turned off and the suspended solids allowed to settle for 4-6 hr. Thereafter, the supernatant effluent is discharged through a 10.2 cm (4 in) PVC pipe at a level of 25.4 cm (10 in) above the bottom of the tank. The discharge pipe is connected at least 25.4 cm (10 in) above the bottom of the tank so that the layer of activated sludge near the bottom is not drawn off at the time of discharge. When all 15 raceways are in use, the wastewater effluent is discharged three times a week into a storm sewer at a rate of about 47,100 liter (12,450 gal) per discharge.

Hydrogen peroxide ( $H_2O_2$ ) is injected as the wastewater effluent is discharged. Concentration of the injected  $H_2O_2$  is 60-100 ppm in the effluent discharged through the 10.2 cm pipe. The  $H_2O_2$  is applied with an injector pump (Fig. 12) outfitted with a calibrated flow meter (Table 3).

A 2.54 cm (1 in) sampling pipe was installed in the 10.2 cm wastewater drain line approximately 12.2 m (40 ft) from the digestion tanks (Fig. 13). During each discharge cycle, a three-aliquot sample of the treated wastewater effluent is taken to determine average salinity, pH, total organic carbon (TOC), and total suspended solids (TSS) (Table 4). Aliquots of 250 ml each are taken at the beginning, midpoint and end of the discharge cycle. The samples are analyzed for TOC by a private contractor. The pH is determined with a pH meter. TSS are determined for a 250 ml aliquot of effluent using GF/C filters and a millipore filter. The filtrate is dried in an oven at 105°C and weighed. The results of TSS and TOC analyses (Table 3) are reported monthly (in pounds/day) to the Texas Department of Water Resources, Water Quality Board, Austin, Texas under permit no. 02299.

After the wastewater effluent discharge is completed, the discharge lines are flushed with 1,136 liter (300 gal) of freshwater to which had been added 1.5 liter of  $H_2O_2$ . Currently, the treated wastewater effluent is discharged into a municipal storm sewer. Each

digestion tank also is plumbed from the bottom into the City of Galveston domestic sewerage system (Fig. 13). At the end of each annual head start period, the residual sludge is washed from the digestion tanks into this system.

#### HEAD START OPERATIONS

Receipt of Hatchlings - At the Padre Island National Seashore, hatchlings are packed in wax-coated, cardboard boxes (58.4 cm or 23 in long, 40.6 cm or 16 in wide, and 25.4 cm or 10 in deep) containing polyurethane foam padding soaked with water to prevent dessication of the hatchlings. They arrive at Galveston after 2-6 hr in shipment. NPS personnel pack the boxes in such a way that each clutch is kept segregated from others. Upon arrival at the head start facilities, the hatchlings are first rinsed with seawater and then inspected closely for abnormalities and mortality. The most common abnormalities observed are: "cross-beak" (upper and lower jaws grossly malformed, left eye missing); concave plastron (plastron grossly depressed); curvature of the spine; shortened spine (turtle much greater in width than in length); plastron improperly healed (unclosed yolk-sac attachment site) and deformed flippers. Turtles with abnormalities are isolated in the sick bay. Turtles with improperly healed plastrons are treated with a topical antibacterial ointment (Terramycin, Gentamycin, Neomycin, or Furacin), and in most cases this eventually heals. Abnormal turtles that have survived usually have been transferred to Texas A&M University, College Station, Texas, or to the University of Texas Institute of Marine Science, Port Aransas, Texas, to be used for research. A small number of these have been transferred by Texas A&M University to Sea Turtles, Inc., directed by Mrs. Ila Loetscher, South Padre Island, Texas.

Weighing and Measuring - Either before they are transported to Galveston or immediately upon their arrival (i.e., during the rinsing and inspection processes), all hatchlings are weighed (wet weight) and measured (carapace length and width; as recommended by Bjorndal and Balazs 1983). Similar measurements are made on random samples taken once per month thereafter and are recorded to the nearest 0.1 g. It has been determined that a minimum of 25 turtles, by clutch, is an adequate sample of turtles from a given raceway per month (Caillouet et al.<sup>1/</sup>). During the weighings, no attempt is made to dry the turtles. After consecutive weighings of three turtles, the balance pan is dried and re-zeroed. An Ohaus, triple-beam balance is used.

Assignment of individual turtles from a given clutch to a given raceway and distribution of portions of clutches to different raceways currently is determined according to experimental design. In the past, clutches were placed in raceways more or less sequentially as they were received from NPS, starting with raceway 1 and progressing consecutively among the numbered raceways.

Clutch identity of each turtle is monitored through the bucket identification code. The numbering system used within a raceway is shown in Fig. 14. For instance, the bucket marked with an X in Fig. 14 is labeled 83-1-G-4. This code indicates that the turtle was from the 1983 year-class and was located in raceway 1, in the bucket in row G and column 4. Such codes, once assigned to individual turtles, are used throughout the head starting process to track individual turtles. In this way, the history of a given turtle can be tracked back through head starting for information on its maternal parentage and details about egg laying, egg collection, incubation, hatching, growth, amount of food fed, health care, etc. For tagged turtles released, the tag number can be linked with the identification code used during head starting. Computerized data files carry this identification code to track data for each turtle.

Feeding - The food used in the head start project has been a commercially prepared, dry, pelleted diet (Table 5) manufactured by Central Soya and Subsidiaries, Fort Wayne, Indiana. In 1978, the first year of operation, natural foods such as lettuce, fillet of croaker, fillet of freshwater sawfish and fillet of whiting were fed (McVey et al.<sup>4/</sup>), but the cost and inconvenience of using such foods are prohibitive. The diet prepared by Central Soya contained 45% crude protein, 5% crude fat, 3% crude fiber, and 47% other ingredients (including, but not necessarily limited to, moisture). This provided good growth (Fig. 1) and survival (Table 1) of the turtles.

One problem encountered with the Central Soya food was its contamination by small, unidentified beetles when it was stored in a dry, air-conditioned room. Apparently, the food itself was contaminated with the eggs of the insect, but this was never confirmed. The problem with the beetles was eliminated, beginning in 1982, by keeping the food in frozen storage until use. Floating pellets are essential, both to facilitate feeding at the surface and to avoid loss of food through the holes in the bottom of the buckets. The hatchlings and older turtles are capable of diving to the bottom of the buckets to feed, but the feed disintegrates in time. Thus, surface feeding is encouraged, and this requires floating food.

Feeding of hatchlings must be carefully monitored as overfeeding can result in compaction of the gut that may lead to death. Because

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<sup>4/</sup>McVey, J. P., J. K. Leong, R. S. Wheeler and R. M. Harris. The culture of young Kemp's ridley sea turtles (Lepidochelys kempi). Unpublished manuscript, NMFS SEFC Galveston Laboratory, Galveston, Texas.

sacrificing live, healthy hatchlings is prohibited, no direct way has yet been developed to determine when the yolk material has been adequately absorbed so as to determine when feeding should start. During the first five years of head starting, commencement of feeding was determined subjectively based on the apparent willingness of hatchlings to accept food, usually at 5-7 days of age.

Twelve apparently healthy hatchlings of the 1983 year-class were isolated in basins in the sick bay, and were weighed on a Mettler balance every day (at the same time of day) for 18 days. Over a period of 17 days, none of the twelve hatchlings lost weight; in fact, their average weight went from 17.3 to 21.4 g. The study was terminated on the 18th day because of concern for the overall health of the hatchlings. One of the test turtles died two days after the study was terminated. Necropsy showed that this turtle died from an invasive fungal infection, rather than from lack of food. Interestingly enough, there appeared to be no significant reduction in the overall volume of its yolk-sac.

The rate at which head started turtles are fed is based on the average weight of a sample of surviving turtles at monthly intervals during head starting. Average weight was estimated by weighing a randomly selected sample of 375-450 turtles (25-30 per raceway). The initial rate of feeding for hatchlings is roughly 5% of body weight. This rate is subjectively changed each month until a rate of roughly 1.5% of body weight is reached for yearlings. The daily food ration is usually divided into two equal portions, one fed in the early morning and the other in late afternoon. The total amount of food to be fed to the turtles on a given day is calculated by multiplying the average weight of the sample of turtles by the total number of survivors. The rations of food are distributed by personnel to the turtles by hand, subjectively attempting to take into account the size of each turtle, by feeding more or less food to the larger or smaller turtles, respectively.



Growth - Growth and survival of head started Kemp's ridleys of the 1978-1983 year-classes has been described in detail by Caillouet et al.<sup>1/</sup>. We have plotted the arithmetic average weight (kg) against elapsed time (days) for the 1978-1983 year-classes in Figure 1.

Health Care - During head starting, each turtle receives a precursory examination for evidence of disease during the twice daily feeding. Once every ten days, each turtle is examined closely for signs of disease and/or injury. Any turtle displaying signs of disease or injury is isolated at that time in the sick bay. Those with minor ailments, such as skin lesions, are treated in the sick bay; others with more serious problems are submitted to the pathologist, Dr. Jorge Leong<sup>5/</sup>, for clinical diagnosis and treatment (Clary and Leong 1984). Many of the prophylactic, diagnostic and therapeutic methods used during head starting of Kemp's ridleys were developed or adapted by Dr. Leong and his staff. Signs of turtle diseases and actions taken were as follows:

- a) Apparent disorientation - The condition is noted and observations are made on the turtle twice daily. If the condition persists for more than 48 hours the pathologist is consulted.
- b) Superficial dermal and shell lesions - Most lesions respond to daily topical applications of Terramycin (oxytetracycline hydrochloride ointment combined with polymyxin B sulfate). More persistent lesions were treated with Furacin (nitrofurazone), a topical antibacterial agent, but we use it as a last resort because the polyethylene glycols present in the base can be

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<sup>5/</sup>Leong, J. K., D. L. Smith, D. B. Revera and J. C. Clary III.

Health care and diseases of captive hatchlings of the loggerhead and Kemp's ridley sea turtles. Unpublished manuscript, NMFS SEFC Galveston Laboratory, Galveston, Texas.



absorbed through the skin and may cause renal impairment. If lesions do not appear to respond to treatment within 5 days, the pathologist is consulted.

- c) Buccal or anal hemorrhaging - The pathologist is notified at once and the entire raceway is isolated from the general seawater supply and wastewater discharge systems. This condition is indicative of a potential epizootic of bacterial etiology with possible severe consequences (e.g., hemorrhagic septicemia leading to death). The entire head start staff is placed on alert and feeding of turtles in the affected raceway(s) is discontinued.
- d) Cloacal prolapse (tissue extruding from the anus of the turtle) - Antibacterial ointment is applied topically to the affected area for 48 hours; if there is no improvement, the pathologist is notified.

Tagging - The tags used for all head started sea turtles are Hasco type, style 681, self-piercing, self-clinching, ear tags, manufactured from monel metal (National Band and Tag Co.). They are inscribed with a sequential letter-number code as well as the message "Send NMFS Lab, Virginia Key, Miami, FL 33149." Tagging with this tag is usually done about 30 days prior to release of the turtles to allow remedial action in case of tag loss, infection, or any tag-related mortality. The tags are normally inserted on the trailing edge of the right front flipper; double-tagged individuals also are tagged on the left front flipper (Fig. 15). The tags used on the 1978-1981 year-classes were first soaked in gasoline for 24 hours to remove any oil or grease, then in 90 percent ethanol for 24 hours prior to use. Tags used with the 1982 year-class received no treatment prior to application, and an outbreak of hemorrhagic septicemia ensued. Thereafter, the tags used on the 1983 year-class were sterilized by autoclaving prior to tagging.

The area of tag insertion on the flipper is swabbed with tincture of iodine prior to tagging, then Neosporin, a broad-spectrum antibacterial ointment, is applied to the tip of the sharp clasping device of the tag before the tag is inserted. A heavy, cast-iron, tagging tool supplied by National Band and Tag Co. is used to affix the tag to the flipper. It is sometimes necessary to recrimp the tag with pliers to secure it. Careful observations of tag numbers, body weight, carapace length, carapace width, and gross observations of general turtle condition and health are made and recorded as each tag is applied. This usually has been the last time that measurements and weights of the head started turtles were recorded before the tagged turtles were released. Turtles do not actively feed for 1-2 days after tagging, so feeding is discontinued for 48 hours. This procedure eliminates fouling the water with uneaten food. Some head started turtles of the 1978, 1979, and 1980 year-classes were outfitted with radio transmitters. The results of tracking studies on these turtles have been reported by Klima and McVey (1981), McVey and Wibbels (1984), and Wibbels (1984).

Transportation to Release Sites - Head started Kemp's ridleys are transported to release sites or marine aquaria in wax-coated, cardboard boxes (the type used to transport hatchlings from Padre Island to Galveston). The boxes are modified by partitioning them with plywood to make two horizontal "layers" within each box (Fig. 16). Two 1.27 cm ( $\frac{1}{2}$  in) air-holes are drilled at each end of the box and the floor of each layer is covered with a piece of 1.27 cm thick polyurethane foam to cushion the turtles. The foam is moistened to prevent dessication of the turtles during transit. Eight yearling turtles are transported in each box, four turtles to a layer. Turtles are oriented with their heads toward the corners to prevent them from biting each other, and to place their heads near the air-holes. The lid of the box is secured with gray, duct tape, one piece completely around the length of the box and another completely around the width.

Copies of Federal and State permits are attached to each box. Normally, a crew of ten persons requires 3 hours to pack and load 1,600 tagged yearling turtles for shipment. Packing and loading should be done as quickly as possible to reduce the amount of time that turtles are held in the boxes.

Release - The release sites, dates of release, and tag series used for release of head started Kemp's ridley sea turtles from the 1978-1983 year-classes are presented in Table 6. Most tagged turtles of the 1978 and 1979 year-classes were released in Florida waters because most yearling Kemp's ridleys had been observed to occur in that area (Klima and McVey 1981; McVey and Wibbels 1984). Some of the 1978 and 1979 year-classes were released off Padre Island (ibid.). Most of the 1980-1983 year-classes were released offshore of Padre and Mustang Islands, Texas, in hopes of reinforcing any imprinting they might have received as eggs and hatchlings<sup>2/</sup>. Some of the 1980 year-class were released off Campeche, Mexico, and some of the 1982 year-class were released in Nueces Bay and off Sabine Pass, Texas. Most of the 1980 and 1981 year-classes were released from the TPWD research vessel "WESTERN GULF". Most of the 1982 year-class and all of the 1983 year-classes were released from the U.S. Coast Guard cutter "POINT BAKER". The portion of the 1982 year-class released in Nueces Bay, Texas, was released from a TPWD boat. Three groups of turtles tagged with radio transmitters were released from small boats and were tracked by aircraft (Klima and McVey 1981; McVey and Wibbels 1984; Wibbels 1984).

Tagged turtles are usually released by dropping them over the side of the vessel into the water. Almost without exception, they will beat their flippers so rapidly that they give the impression of "flying" across the surface of the water, sometimes to distances estimated to be around 30.5 m (100 ft), before submerging.

## SEA TURTLE HEAD START RESEARCH AND GENERAL OBSERVATIONS

### Recaptures of Head Started/Tagged/Released Turtles

In general, tagged Kemp's ridleys have become widely dispersed in U.S. waters, from Brownsville, Texas, along the coast of the Gulf of Mexico, to the U.S. eastern seaboard as far north as Long Island, New York (Klima and McVey 1981; Caillouet 1984; McVey and Wibbels 1984; Wibbels 1984; Fontaine et al.<sup>2/</sup>). Foreign recoveries have been reported from France, Morocco, Dominican Republic (unconfirmed), and the Mexican coast of the Gulf of Mexico<sup>2/</sup>. Although the reports of measurements on recovered turtles are scanty and not always reliable, available data indicate good growth rates (averaging 5 g per day) of the head started, tagged Kemp's ridleys in their natural environment<sup>2/</sup>. The turtle at large for the longest period (1,563 days or 4.3 yr) was from the 1978 year-class, and was recovered from Hunting Island, South Carolina, on August 18, 1983 after release from Homosassa, Florida on May 8, 1979.

Most tagged Kemp's ridleys have been recovered alive (Table 7) and returned to the environment<sup>2/</sup>; however, in many cases the flipper tag was removed before the turtle was re-released because the inscription on the tag encourages such removal. Consideration should be given to changing the message inscribed on the tags so that the recovery information is retained, but the tag is left intact when a live turtle is re-released.

Of those turtles from the 1978 and 1979 year-classes released in Florida, all recoveries from the former year-class and most of the recoveries from the latter year-class have been made on the east coast of the United States as far north as Long Island, New York<sup>2/</sup>. Carr (1980) postulated that juvenile Kemp's ridley sea turtles found in the Atlantic Ocean, particularly those along the Atlantic coasts of North America and Europe, are lost "waifs" that never return to the Gulf of Mexico. Head started Kemp's ridleys survive, overwinter, and grow normally in the Atlantic, and they may return at some later date to

the warmer waters of the Gulf of Mexico where the breeding population of Kemp's ridleys is found<sup>2/</sup>. Most recoveries from the 1980-1983 year-class released off Padre Island have been made in the western Gulf of Mexico.

Feeding Regimen and Food Utilization - After 1980, all year-classes were fed only a dry, pelleted diet (Table 5). The utilization of this foodstuff, incidence of feeding, and rate of feeding have been investigated for the 1978-1981 year-class by McVey et al.<sup>4/</sup>. In general, our observations indicated that the gross food conversion ratio (total weight of food fed:total amount of weight gained) for turtles fed this commercially prepared diet was good, ranging from 1.3:1.0 to 1.7:1.0 in the 1982 and 1983 year-classes, respectively. This is particularly impressive since all the food offered was not always eaten. The Kemp's ridley sea turtle evidently possesses very efficient digestive and metabolic systems. It would appear from these data that Kemp's ridleys head started in buckets at the Galveston Laboratory require a very small amount of food to meet daily dietary needs for maintenance. Confinement in buckets may limit the scope of activity and thereby reduce the expenditure of energy (Caillouet et al.<sup>1/</sup>). Turtles head started in captivity gained at an average rate of only 3 g per day during the first year of life. This was slower growth as compared to post-release growth in the natural environment (5 g/day), but it is to be expected if the animals released were still in the exponential phase of growth for a time after their release. In general, growth in captivity is more rapid than growth in the wild (Caillouet 1984; McVey and Wibbels 1984; Caillouet et al.<sup>1/</sup>).

Food Color Preference - During the manufacture of the fiberglass basins, one basin evidently was splattered with a drop of bright red paint. We noticed that any turtle placed in this basin would invariably "worry" or peck at this spot continually during daylight hours. Further, we observed that hatchling and yearling turtles



reacted (by rapid movement) to personnel dressed in red, orange, yellow, or white, while they responded much less to those dressed in darker colors such as black, green, blue, or brown.

Therefore, we designed a study to test possible preferences of head started Kemp's ridleys for foodstuff colored with different food dyes (Appendix 1). Pieces of fresh, abdominal muscle of shrimp were soaked overnight in Kroger, Inc. food coloring (either red, yellow, blue, or green). Pieces of colored food and non-colored (control) food were affixed to a special food holder (Fig. 17) in randomized order. Four colored (red, yellow, blue and green) pieces and one uncolored (control) piece of shrimp were presented on the holder to each of 20 turtles in each of three different consecutively tested groups. The pieces of shrimp were placed on the holder randomly for each turtle tested, so that their location on the holder would not be confounded with treatments (different colors and control). Each turtle was allowed to bite at the food twice to determine its first and second choices. After the first choice (or bite) was made, the holder was flipped over so that the order of food on the holder was reversed before the second choice or bite was made. Any food item removed on the first bite by the turtle was replaced at the same position by an item of the same color as that removed.

The dominant choice of colored shrimp muscle was for pieces colored red, for both first and second choices (Table 8). Possibly the turtles were also reacting to a chemical stimulus created by the food coloring dye itself, as the chemical makeup of the different colors of food dyes is not the same. However, we believe that the choice was based primarily on optical rather than olfactory or other chemo-sensory mechanisms. This is reinforced by the previously observed reactions of turtles to the red spot in one of the basins, and to colored clothing worn by project personnel.



Celestial Orientation of Hatchlings - Another study was conducted in cooperation with the Burke Baker Planetarium in Houston, Texas, to test celestial orientation in head started hatchling Kemp's ridley sea turtles of the 1983 year-class. The primary objective of the study was to determine if hatchlings that had never seen the stars would demonstrate any ability to orient relative to celestial patterns (assuming they had not seen stars before we received them; they were kept inside the boxes during transit, and in the quonset hut thereafter).

Observations were made on 4 different hatchlings, each tested alone. A hatchling was placed in a submersible pen positioned in the center of a fiberglass basin (similar to the ones in the standing basin unit) located within the planetarium and oriented on a compass rose for true magnetic north. After a turtle had acclimated for 15 minutes within the small pen, the pen was released and sank to the bottom "freeing" the turtle. After the turtle was released, two types of observations were made: (1) the initial position to which the turtle traveled on the periphery of the basin; and (2) the position of the turtle around the periphery of the basin at 1 min intervals. The number of observations depended upon the amount of time allotted for use of the planetarium. All four turtles used in this study were tested on four different occasions: July 28, 1983, August 4, 1983, August 11, 1983, and September 8, 1983, and two of them were tested twice on an additional day, September 16, 1983.

The initial position to which the turtles traveled (Table 9) appeared to be random with regard to east-west orientation (10 to the west and 9 to the east), but the direction traveled after initial contact with the side of the test basin was predominantly in a clockwise motion; however, after the first few minutes all turtles would randomly "wander" around the periphery of the test basin. The observations of orientation of turtles within the basins with time (Table 9) showed that the test turtles appeared in the western half of the test basin more often than in the eastern half (62%:38%,

respectively).

We recognize that these observations are insufficient to draw definite conclusions. It would appear from these preliminary data that head started turtles showed a particular preference for the western half of the test basin as compared with the eastern half. Whether or not this represents celestial orientation remains to be determined.

Re-Cycled Seawater - The seawater system at the Galveston Laboratory does not have the pumping or storage capacity to allow for flow-through at rates sufficient for daily replacement of water in all of the raceways (approximately 520 gal/hr; 33 ml/min). The water quality deteriorates rapidly prior to cleaning the raceways (Fig. 18), due to accumulation and decomposition of turtle waste products and uneaten food. Therefore, we investigated the feasibility of using re-cycled seawater. The system tested included an external Permutube settler and a rotating biological contactor (biodisc). In general, this system significantly reduced the rate of increase in concentration of dissolved organics, particularly that for total ammonia, as measured by ammonia-nitrogen (Fig. 19). While this system seems promising, flow-through systems might be preferable for head starting sea turtles, but have the possible disadvantage of inflating costs of heating the seawater.

The laboratory procedures used for analyses of total ammonia, nitrite, nitrate, and phosphate in seawater are presented in Appendix 2. Descriptions of various seawater treatment systems and biological operation of such systems are presented by Wheaton (1977).

Tagging - Various tagging methods have been investigated during head starting of the Kemp's ridley sea turtles. Double-tagging with monel metal flipper tags was first tried on 54 turtles of the 1981 year-class and later on 400 turtles from the 1982 year-class to increase the probability that at least one flipper tag would be

retained. As of October 1, 1984, 32 individuals (7.5%) of 424 doubled-tagged turtles released off the Texas coast had been recovered, as compared with 191 (7.9%) recovered out of 2,428 single-tagged animals released from the 1980 and 1982 year-classes combined. However, the double-tagged turtles that were released into the environment have not been at-large long enough to ascertain the value of the second tag.

Another observation was that double-tagged turtles were more lethargic after tagging and took longer to begin feeding after tagging than those that received a single tag. Double-tagging appears to be more traumatic. The tags used for tagging the 1982 year-class were not sterilized and an infection ensued. This problem probably can be avoided by sterilizing the tags before tagging.

A "living-tag" technique developed by Dr. John and Mrs. Lupe Hendrickson, University of Arizona, Tucson, Arizona, involves surgical removal of pieces of plastron and carapace, interchanging the grafts, and securing them with histological glue. As the turtles grow, the lighter colored plastron transplant makes a vivid mark on the darker background of the carapace.

Three "living-tag" experiments were conducted. The first two were conducted in cooperation with Dr. and Mrs. Hendrickson and the last by NMFS personnel. The first was done on 200 turtles ("living-tagged" on right coastal skutes 2, 3, or 4) of the 1980 year-class and the second on 432 turtles ("living-tagged" on left coastal skate 3) of the 1982 year-class. In the third experiment, all turtles from the 1983 year-class were "living-tagged" on left coastal scute four. The lighter-colored plastron transplant contrasted with the darker carapace within the first 90-120 days after tagging turtles 5-7 months old (first and second experiments). After this time, the mark, in some cases, began to fade or blend in with the surrounding carapace that becomes lighter in color as the turtle ages. Retention of the mark was not good in the second experiment (1982 year-class; Table 10).

Twenty-five head started Kemp's ridleys of the 1982 year-class

were sent to five public marine aquariums, five per location (Table 2). Each turtle had been tagged with an internal, binary-coded, metal tag manufactured by Northwest Marine Technology Co., Shaw Island, Washington. The tag was inserted beneath the skin of the right front flipper near the distal end of the humerus (Fig. 20). Since these turtles are being held in captivity beyond their first year, observations can be made on tag retention, tag migration (if any) within the tissue, and tag detection and decoding with x-ray equipment. Some of these turtles also are marked with the "living tag" allowing opportunity for examination as they grow older and carapace color lightens.

General Observations - Kemp's ridleys having dermal lesions were placed outside in sunlight for 2-4 hr. This exposure to sunlight seemed very effective for treating certain skin lesions. Further, turtles that became sick during head starting and then received the "sunshine treatment" appeared to be much more active, had better appetite, and were, in general, in better overall condition than sick turtles that did not receive the treatment.

One problem encountered was excess growth of filamentous green algae on the young turtles. In early years, the turtles were periodically scrubbed with soft brushes to remove this algae. Starting in 1981, this practice was discontinued because it was thought that scrubbing might remove natural protection, such as a mucus-layer. The algae growth probably was stimulated by the excessive levels of nitrogenous compounds within the holding water and by ample sunlight (90% of the incident sunlight) that penetrated the polyethylene covering of the quonset hut. At 7 to 8 months of age, or at a body weight near 454 g (1 lb), the turtles began to lose much of the attached algae. With turtles held for longer periods we noticed that by the age of 12 months all normal sized turtles had lost the attached algae. It may be that, beyond a certain size or age, the Kemp's ridley's produce epidermal substances that prevent fouling growth on the shell. This is suggested as an area for further research.

One of the more unusual and unanticipated behaviors was the variation in the reaction of head started turtles to different personnel working within the project. Most of the time, the turtles, especially yearling and older, would react violently when picked up. In most cases, when picked up by hand, the turtles would rapidly beat their flippers and attempt to bite the person holding them. Also, when the turtles were larger and held in standing basins, they would splash water on a person approaching their basins. The turtles did not react in this way to one of the coauthors (Kathy L. Williams Indelicato) of this report. When she picked up any of the turtles they would immediately become very still and would not move until placed back into their buckets. Also, regardless of the type or color of clothing she wore, the larger turtles in the standing basins would not react and would float very still on the surface until Mrs. Indelicato had passed. This observation and others are anecdotal, but, for those involved in caring for and handling the aggressive Kemp's ridley sea turtle, they may be of interest.

#### DISCUSSION

Survival and growth of head started Kemp's ridleys in captivity during the first six years of the project are shown in Table 1 and Figure 1 (see also Caillouet et al.<sup>1/</sup>). The combined survival rate for the six year-classes was 82%. The survival and growth of head started Kemp's ridleys in the wild appears to be good (Fontaine et al.<sup>2/</sup>), but it is too early to gauge the success of maturation, copulation and nesting of such animals in the wild (Caillouet 1984). Recently, egg laying was reported in two 5-year-old, head started Kemp's ridley maintained in captivity at Cayman Turtle Farm [1983] Ltd. (Wood and Wood, 1984). According to Wood and Wood (1984), more than 60 eggs were laid by the sea turtles in May 1984. Three of the eggs in one clutch hatched, indicating that copulation and fertilization had occurred. Unfortunately, the three hatchlings did not



live. Nevertheless, this represents a breakthrough in mating and nesting of captive individuals, indicating that head started animals might contribute to a captive breeding population as a "safety net" for the species (Caillouet, 1984). The potential for maturation and copulation among captive breeding populations of Kemp's ridleys is now less remote than was once thought. The survival and fast growth of eight out of ten head started ridleys from the 1978 year-class at Sea-Arama Marineworld in Galveston (Fig. 21) is very encouraging (McVey and Wibbels, 1984; Caillouet et al.<sup>1/</sup>).

After six years of involvement in head starting Kemp's ridley sea turtles, we believe that there are four areas of research that should be emphasized in future work:

- (1) Reproductive physiology and behavior as related to reproduction in the wild and in captivity.
- (2) Tags and tagging of sea turtles. None of the tags presently being used adequately meet the needs. A tag or mark is needed that will last the entire life of the tagged turtle, and that can be easily recognized and identified by whomever recaptures a Kemp's ridley. Further, through publicity and through changes in the message on the tag, the finder of a tagged turtle must be encouraged to take the needed observations and report them in a timely manner without removing the tag from live animals. Removal of the tag from dead animals should be encouraged as part of the reporting of stranded sea turtles.
- (3) Sex determination. A simple technique must be developed to determine the sex of live hatchlings and older immature individuals without injuring them. Sex determination is essential for proper management and conservation of this endangered species, because sex ratios of hatchlings may be



affected by incubation temperature. The hormonal studies by Dr. David Owens, Texas A&M University, and his students are encouraging in this regard. Laparoscopy also has been used successfully by Owens and his students on larger juvenile and adult turtles, but neither technique is simple nor applicable to hatchlings.

- (4) Prevention, recognition, diagnosis, and treatment of diseases among captive populations of Kemp's ridleys must be improved. The successful establishment of captive breeding populations of Kemp's ridleys will, in our opinion, depend to a large extent upon solutions to the disease problems encountered in the husbandry of this species. Improvements in seawater systems toward providing high quality seawater for captive rearing of sea turtles would go far toward reducing disease problems. Other environmental influences (e.g., sunlight, temperature, etc.) also may affect the incidence of disease. Good nutrition is another important factor.

#### EPILOGUE

Prior to arrival of the first group of Kemp's ridley sea turtle hatchlings at Galveston in 1978, very little was known about the husbandry of this endangered species (Marquez 1972; Pritchard and Marquez 1973). Little if anything was known of their spatial needs, what to feed them, how to recognize or to treat their diseases, nature of their behavioral characteristics, seawater quality requirements, or any of their other day-to-day needs. Information was available from comparable work done on other sea turtle species, but it was soon apparent that many of these procedures were not applicable to the Kemp's ridley. Consequently, many of the techniques and equipment developed, adapted and used at the NMFS Galveston Laboratory were the results of experimental and trial-and-error approaches as well as

serendipitous findings. For instance, in 1978 no one expected the aggressive behavior, exhibited among Kemp's ridley hatchlings, that necessitated isolation of each hatchling in an individual container (Klima and McVey 1981). The suspended, plastic bucket system that evolved seems simple in hindsight. However, its development required considerable observation and effort on the part of Bonnie Cockrell, Clark Fontaine, Larry Lansford, Jorge Leong, Cornelius Mock, Dickie Revera, and Ray Wheeler over a period of time (Clary and Leong 1984<sup>4</sup>/).

The head start facilities themselves have been modified a number of times during the tenure of the project (Fig. 22). The changes in 1981 were made to provide a sick bay, to improve wastewater treatment, to provide a maintenance shop and tool storage areas, and to increase seawater storage capacity. The modifications following Hurricane Alicia in 1983 were made in an effort to reduce utility costs through more efficient heating, to facilitate replacement of polyethylene covers, and in an attempt to provide better seawater quality.

All authors of this report, at one time or another, were closely involved in the day-to-day care and husbandry of Kemp's ridleys, and they feel honored to have been a part of the international effort to save this endangered species from extinction. Our sincere hope and wish are that the head starting of Kemp's ridleys be continued. We support and encourage all efforts toward the conservation of the Kemp's ridley sea turtle. William Beebe made the apocalyptic observation that "when the last animal of a race of living things breathes no more, another heaven and earth must come to pass before such a one can be again."

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Table 1. Summary of head start results for Kemp's ridley sea turtle year-classes, 1978-1983.

Year-class	Number of live hatchlings received	Number of dead hatchlings received	Mortality during head starting	Number of head start survivors	Percent survival <sup>a/</sup>	Number of turtles held back for research <sup>b/</sup> and captive brood stock	Number of tagged turtles released	Percent released <sup>a/</sup>	Number of tagged turtles recovered <sup>c/</sup>	Percent recovered
1978	3,080	1	992	2,088	67.8	42	2,019 <sup>d/</sup>	65.6	75	3.7
1979	1,843	3	315	1,530	83.0	166	1,345 <sup>e/</sup>	73.0	18	1.3
1980	1,815	7	84	1,731	95.4	0	1,723 <sup>f/</sup>	94.9	84	4.9
1981	1,864	1	225 <sup>g/</sup>	1,639	87.9	0	1,639	87.9	46	2.8
1982	1,524	0	171	1,353	88.8	28	1,325	86.9	149	11.2
1983	250	0	58	192	76.8	2	190	76.0	6	3.2
Total	10,376	12	1,845	8,533	82.2	238	8,241	79.4	378	4.6

<sup>a/</sup>Based on number of hatchlings received alive.

<sup>b/</sup>These were abnormal, injured or sick individuals that could not be released.

<sup>c/</sup>As of February 1, 1985.

<sup>d/</sup>27 turtles died in transit.

<sup>e/</sup>17 turtles died in transit.

<sup>f/</sup>8 turtles died in transit.

<sup>g/</sup>Included 2 turtles unaccounted for but presumed dead.

Table 2. Tag numbers and other information for head started, Kemp's ridley sea turtles of the 1982 year-class distributed to five public marine aquaria.

Recipient	Clutch No. <u>a</u> /	Date Shipped	"Living- Tagged" <u>b</u> /	Internal Tag <u>c</u> / Code	Flipper Tag Codes <u>d</u> /
Clearwater Marine Science Center Clearwater, FL	9	11-9-83	No	(D <sub>1</sub> -2;D <sub>2</sub> -20)	NNM 106/107
	9	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -21)	NNM 154/155
	12	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -32)	NNM 193
	12	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -33)	NNM 251/252
	10	"	Yes	(D <sub>1</sub> -2;D <sub>2</sub> -34)	NNM 330
Key West Municipal Aquarium Key West, FL	6	11-9-83	No	(D <sub>1</sub> -2;D <sub>2</sub> -68)	NNL 902/903
	7	"	Yes	(D <sub>1</sub> -2;D <sub>2</sub> -64)	NNM 026
	8	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -40)	NNM 406
	11	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -41)	NNM 448
	19	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -42)	NNM 576
Theater of the Sea Islamorada, FL <u>e</u> /	10	11-9-83	Yes	(D <sub>1</sub> -2;D <sub>2</sub> -36)	NNM 353
	7	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -65)	NNM 023/024
	6	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -66)	NNL 917
	8	"	Yes	(D <sub>1</sub> -2;D <sub>2</sub> -37)	NNM 375
	5	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -69)	NNL 682/683

Table 2. continued

Recipient	Clutch No. <sup>a/</sup>	Date Shipped	"Living- Tagged" <sup>b/</sup>	Internal Tag <sup>c/</sup> Code	Flipper Tag Codes <sup>d/</sup>
Gulfarium	4	1-26-84	No	(D <sub>1</sub> -2;D <sub>2</sub> -2)	NNL 485/486
Ft. Walton Beach, FL	3	"	Yes	(D <sub>1</sub> -2;D <sub>2</sub> -5)	NNL 437/438 (died 5-29-84)
	3	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -8)	NNL 297/298
	4	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -4)	NNL 475/476
	20	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -9)	NNM 994
Marine Life Park, Inc., Gulfport, MS	5	2-6-84	No	(D <sub>1</sub> -2;D <sub>2</sub> -1)	NNL 665-666
	18	"	Yes	(D <sub>1</sub> -2;D <sub>2</sub> -10)	NNM 872
	17	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -16)	NNM 835
	16	"	No	(D <sub>1</sub> -2;D <sub>2</sub> -17)	NNM 790
	15	"	Yes	(D <sub>1</sub> -2;D <sub>2</sub> -18)	NNM 703

<sup>a/</sup>Used by NPS, PINS and NMFS Galveston Laboratory.

<sup>b/</sup>"Living tags" were placed on left costal skate 3 (LC3).

<sup>c/</sup>Manufactured by Northwest Marine Technology Inc., Shaw Island,  
Washington.

<sup>d/</sup>Monel metal tags. A single number indicates a tag on the right front flipper. Two numbers separated by a slash indicate double-tagging (i.e., tags on left and right front flippers, respectively).

<sup>e/</sup>These turtles were transferred from Turtle Kraals, Key West, FL to Theater of the Sea, Islamorada, FL on April 16, 1985.



Table 3. Specifications, uses, and suppliers of various equipment and material used in the head start project, 1978-1984<sup>a/</sup>.

Equipment Description <sup>a/</sup>	Use of Equipment	Equipment Supplier <sup>a/</sup>
Fiberglass raceways, basins, digestion tanks, and seawater reservoirs	Holding turtles, treating wastewater, and storing seawater	Red Ewald, Inc. P. O. Box 519 Karnes City, TX 78118-0519
Positive air blowers, 2.7 HP (Cyclonair #CH5)	Aeration of digestion tanks	Rotron, Inc. Mansfield, OH
Hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> ) Injector pump (Pulsafeeder #680-S-E)	Wastewater discharge effluent treatment by injection	FMC Corporation Specialty Chemicals Div. Buffalo, NY 14240
Centrifugal pump, 2 HP (Gorman-Rupp #B0024FGF2A4)	Seawater delivery	Pump & Power Equip. Co. 800 Harwin Dr., Suite 370 Houston, TX 77036
Submersible sump pump 140 gal/min at 5 ft head (Teel pump #3P650)	Pumping untreated wastewater	Granger, Inc. 7777 Parnell St. Houston, TX
Plastic buckets, 11 qt volume, 28 cm diameter, 22 cm depth	Containers for individual sea turtles	Loma Plastics, Inc. Fort Worth, TX
Quonset hut covers (Loratex, UV treated)	Tops for quonset huts	Farm Supply Co. 500 Clarkesville St. Cornelia, GA 30351
Titanium immersion heaters	Heating seawater in reservoirs	Glo-Quartz Elec. Heater Co. 7074-7190 Maple St. Mentor, OH 40051
Hydrogen peroxide, 35%	Treating sea turtle wastewater discharge	Accron Chemical Dist. 4700 Blaffer Houston, TX 77026

<sup>a/</sup> Mention of trade names or commercial products does not imply endorsement or recommendation for use.

Table 4. Monthly wastewater discharge effluent quality variables.

Arithmetic Averages					Ranges			
Year & Month	Salinity, ppt	pH	TOC <sup>b</sup> /, mg/l,	TSS <sup>c</sup> /, mg/l,	Salinity, ppt	pH	TOC <sup>b</sup> /, mg/l,	TSS <sup>c</sup> /, mg/l,
1981								
July	NT <sup>a</sup> /	NT	NT	NT	NT	NT	NT	NT
August	30	7.3	16.0	52.2	29-30	7.2-7.5	12-22	34-64
September	29	7.7	18.2	40.6	25-38	7.2-8.0	10-28	30-58
October	28	7.9	12.1	29.1	27-29	7.8-8.1	7-21	19-35
November	24	7.4	9.2	25.0	23-26	7.3-7.6	7-14	15-51
December	26	6.6	11.9	27.8	26*	5.9-7.1	5-19	15-43
1982								
January	26	7.2	9.5	30.5	25-28	7.1-7.3	7-11	20-38
February	28	7.2	15.2	29.5	28-30	7.1-7.3	7-16	22-36
March	27	7.7	15.2	31.3	22-29	7.5-8.0	12-24	21-52
April	24	7.4	12.9	36.6	23-25	7.2-7.7	7-24	28-52
May	16	8.0	15.4	40.5	4-24	7.5-8.8	8-22	27-62
June	NT	NT	NT	NT	NT	NT	NT	NT
July	31	7.8	42.1	41.3	31-32	7.7-7.9	13-78	37-46
August	31	8.2	13.4	56.8	28-32	7.7-8.7	10-18	34-69
September	28	8.0	14.5	57.8	24-33	7.5-8.3	8-33	42-77
October	24	7.6	22.3	39.2	20-28	6.8-8.3	17-34	21-51
November	26	7.5	17.5	56.1	23-30	6.3-8.2	12-32	35-93
December	25	7.3	12.1	37.8	22-29	6.0-7.7	7-8	33-50
1983								
January	23	7.5	9.7	47.4	22-24	7.3-8.4	9-10	39-51
February	24	7.5	10.0	46.0	22-25	7.2-8.4	9-10	36-51
March	28	8.3	13.4	47.4	22-29	7.2-7.9	8-25	38-54
April	28	7.8	8.8	40.6	26-30	7.7-7.9	8-10	31-54
May	26	8.5	11.2	30.6	9-36	7.7-8.1	9-16	24-62
June	16	7.9	11.0	56.6	13-20	7.9*	11*	51*

<sup>a</sup>/NT = no turtles were in the facility; thus there was no discharge, so there were no measurements taken.

<sup>b</sup>/TOC = total organic carbon.

<sup>c</sup>/TSS = total suspended solids.

\* = single value or no-variation.

Table 5. Ingredients<sup>a/</sup> of the experimental diet<sup>b/</sup> manufactured by Central Soya and Subsidiaries<sup>c/</sup>, Fort Wayne, Indiana.

---

Plant protein products  
Animal protein products  
Grain products  
Processed grain by-products  
Roughage products  
Lecithin  
Vitamin A supplement  
Vitamin E supplement  
Vitamin B<sub>12</sub> supplement  
Choline chloride  
Niacin supplement  
Calcium pantothenate  
Folic acid  
Riboflavin supplement  
Menadione sodium bisulfite complex  
D-activated animal sterol (source of vitamin D<sub>3</sub>)  
Ascorbic acid  
Biotin  
Pyridoxine hydrochloride  
Thiamine hydrochloride  
Inositol  
Methionine supplement  
Ground limestone  
Calcium phosphate  
Salt and traces of:  
    Manganous oxide  
    Magnesium oxide  
    Ferrous sulfate  
    Calcium iodate  
    Ferrous carbonate  
    Cobalt carbonate  
    Copper oxide  
    Cooper sulfate  
    Zinc oxide

---

<sup>a/</sup>Quantities not available. Proprietary information of Central Soya and Subsidiaries.

<sup>b/</sup>Dry, floating pellets.

<sup>c/</sup>Mention of trade names or commercial products does not imply endorsement or recommendation for use.

Table 6. Summary of Kemp's ridley sea turtle release sites, dates of releases, numbers of turtles released, and tag series used for six year-classes, 1978-1983.

Year-class	Imprint group <sup>a/</sup>	Release Site	Release dates <sup>b/</sup>	No. released	Tag series <sup>c/</sup>
1978	PINS	Sandy Key, FL	2-22-79	135	G----
	PINS	East Cape, FL <sup>d/</sup>	2-22-79	52	G----
	PINS	East Cape, FL	2-28-79	1	13582
	PINS	East Cape, FL	2-28-79	166	G----
	PINS	Sandy Key, FL	3-5-79	172	G----
	RN	Homosassa, FL	5-8-79	751	G----, F----
	PINS	Homosassa, FL <sup>d/</sup>	5-8-79	628	G----, F----
	PINS	Padre Island, TX	7-7-79	112	G----, F----
	RN	Padre Island, TX	7-7-79	1	G0985
	PINS	Homosassa, FL	6-3-80	1	NNA260
1979	PINS	Homosassa, FL (offshore) <sup>d/</sup>	6-3-80	665	NNN---
	RN	Homosassa, FL (nearshore)	6-5-80	66	NNA---
	PINS	Homosassa, FL (nearshore) <sup>d/</sup>	6-5-80	608	NNN---, NNA---
	PINS	Padre Island, TX	6-2-81	5	K----
	PINS	Galveston, TX	9-28-81	1	J0096
1980	PINS	Padre Island, TX	6-2-81	1,426	NNB---, K----
	PINS	Padre Island, TX	6-2-81	100	8001-8100 (Inconel)
	RN	Campeche, MX	3-3-81	197	NNB---, K----
1981	PINS	Padre Island, TX	6-2-82	1,521	NNG---, NNH---
	PINS	Sabine Pass, TX	7-14-82	118	NNG---, NNH---
1982	PINS	Padre & Mustang Islands, TX	6-7-83	1,159	NNL---, NNM---
	PINS	Nueces Bay, TX	6-7-83	96	NNL---, NNM---
	PINS	Sabine Pass, TX	7-15-83	69	NNL---, NNM---
	PINS	Mustang Island, TX	6-5-84	1	NNM428
1983	PINS	Mustang Island, TX	6-5-84	172	NNQ---
	RN	Mustang Island, TX	6-5-84	18	NNQ---
Total				8,241	

<sup>a/</sup>PINS = "imprinted" at the Padre Island National Seashore;  
RN = "imprinted" at Rancho Nuevo.

<sup>b/</sup>Month-day-year.

<sup>c/</sup>Monel metal tags, unless noted otherwise. Each dash represents a numerical digit from 0-9; actual numerical series are not given because they were mixed. Details concerning the numerical series can be obtained from the senior author of this paper.

<sup>d/</sup>This release included turtles also tagged with radio-transmitters (see Klima and McVey 1982; Wibbels 1984).

Table 7. Numbers of reported live and dead recoveries of head started/tagged Kemp's ridley sea turtles of the 1978-1983 year-classes<sup>a/</sup>.

Year-class	Live <sup>b/</sup>	Dead	Unknown <sup>c/</sup>	Total
1978	63	8	4	75
1979	14	3	1	18
1980	46	17	21	84
1981	24	17	5	46
1982	94	48	7	149
1982	5	1	0	6
Totals				
No.	246	94	38	378
%	65.1	24.9	10.0	100.0

<sup>a/</sup>As of May 1, 1985.

<sup>b/</sup>Returned to the environment.

<sup>c/</sup>Information not reported by person making the recovery.



Table 8. Frequencies<sup>a/</sup> of first and second choices by Kemp's ridley sea turtles of pieces of marine shrimp abdominal muscle dyed with food coloring.

Color of Food Chosen Second	Color of Food Chosen First					Totals
	Red	Yellow	Blue	Green	Non-dyed	
Red	171	44	15	25	19	274
Yellow	28	6	3	8	2	47
Blue	15	8	9	7	6	45
Green	37	8	5	12	5	67
Non-dyed <sup>b/</sup>	17	5	7	5	13	47
Totals	268	71	39	57	45	480

<sup>a/</sup>Number of times out of 480 total trials.

<sup>b/</sup>Control.

Table 9. Observations<sup>a/</sup> on celestial orientation of hatchling, head started, Kemp's ridley sea turtles at the Burke Baker Planetarium, Houston, Texas.

Turtle ID Number <sup>b/</sup>	Date <sup>c/</sup>	Azimuth Quadrant				Total No. of Observations <sup>d/</sup>
		1-90°	91-180°	181-270°	271-360°	
1-H-5	7/28/83	1	1	3*	0	5
	8/4/83	1	3*	1	0	5
	8/11/83	1	0	1	3*	5
	9/8/83	<u>0</u>	<u>0</u>	<u>0</u>	<u>10*</u>	<u>10</u>
	Sub-total	3	4	5	13	25
2-H-6	7/28/83	1*	1	2	1	5
	8/4/83	2*	0	3	0	5
	8/11/83	0	0	5*	0	5
	9/8/83	4	0	1	5*	10
	9/16/83 (1st test)	3	0	1	6*	10
	9/16/83 (2nd test)	<u>1*</u>	<u>4</u>	<u>5</u>	<u>0</u>	<u>10</u>
	Sub-total	11	5	17	12	45
2-E-5	7/28/83	0	1	4*	0	5
	8/4/83	3*	0	1	1	5
	8/11/83	2	0	1*	2	5
	9/8/83	1*	0	9	0	10
	9/16/83 (1st test)	2	2	2	4*	10
	9/16/83 (2nd test)	<u>4*</u>	<u>2</u>	<u>0</u>	<u>4</u>	<u>10</u>
	Sub-total	12	5	17	11	45
1-D-4	7/28/83 <sup>e/</sup>	0	0	0	0	5
	8/4/83	0	2	3*	0	5
	8/11/83	0	3*	2	0	5
	9/8/83	<u>1*</u>	<u>4</u>	<u>2</u>	<u>3</u>	<u>10</u>
	Sub-total	1	9	7	3	25
Total		27	23	46	39	140

<sup>a/</sup>Observations on the location of a hatchling were taken immediately at 1-minute intervals. An astrisk (\*) marks the quadrant to which the hatchling first moved after being released from the cage. The numbers in the table indicate the number of times a hatchling was observed in a given quadrant.

<sup>b/</sup>Raceway-bucket row-bucket column.

<sup>c/</sup>Month/day/year.

<sup>d/</sup>Does not include the initial observation after release of the hatchling.

<sup>e/</sup>This turtle displayed no directional response for the five minutes of observation, but stayed in the center of the basin.

Table 10. Results of a "living-tag" experiment in which carapace/plastron tissue grafts were applied by experienced and inexperienced taggers to yearlings of the 1982 year-class of head started, Kemp's ridley sea turtles.

	Type of Mark								Mark Location on Scute											
	Disc		Gouge		Subtotal		% Lost		Central		Posterior		Anterior		Subtotal		Percent Lost			
Tagger	Tagged	lost	Tagged	lost	Tagged	lost	Disc	Gouge	Tagged	lost	Tagged	lost	Tagged	lost	Tagged	lost	Percent lost	Central	Post.	Ant.
Inexperienced																				
Tagger 1	54	29	54	28	108	57	53.7	51.8	36	19	36	20	36	18	108	57	52.8	52.8	55.6	50.0
Inexperienced																				
Tagger 2	54	4	54	0	108	4	7.4	0.0	36	1	36	1	36	2	108	4	3.7	2.8	5.6	3.7
Experienced Tagger 1	54	22	54	14	108	36	40.7	25.9	36	13	36	13	36	11	108	36	33.3	36.1	30.6	33.3
Experienced Tagger 2	54	4	54	5	108	9	7.4	9.2	36	6	36	2	36	1	108	9	8.3	5.6	2.8	8.3
Totals No.	216	59	216	47	432	106	27.3	21.8	144	38	144	36	144	32	432	106	24.5	25.0	22.2	24.5

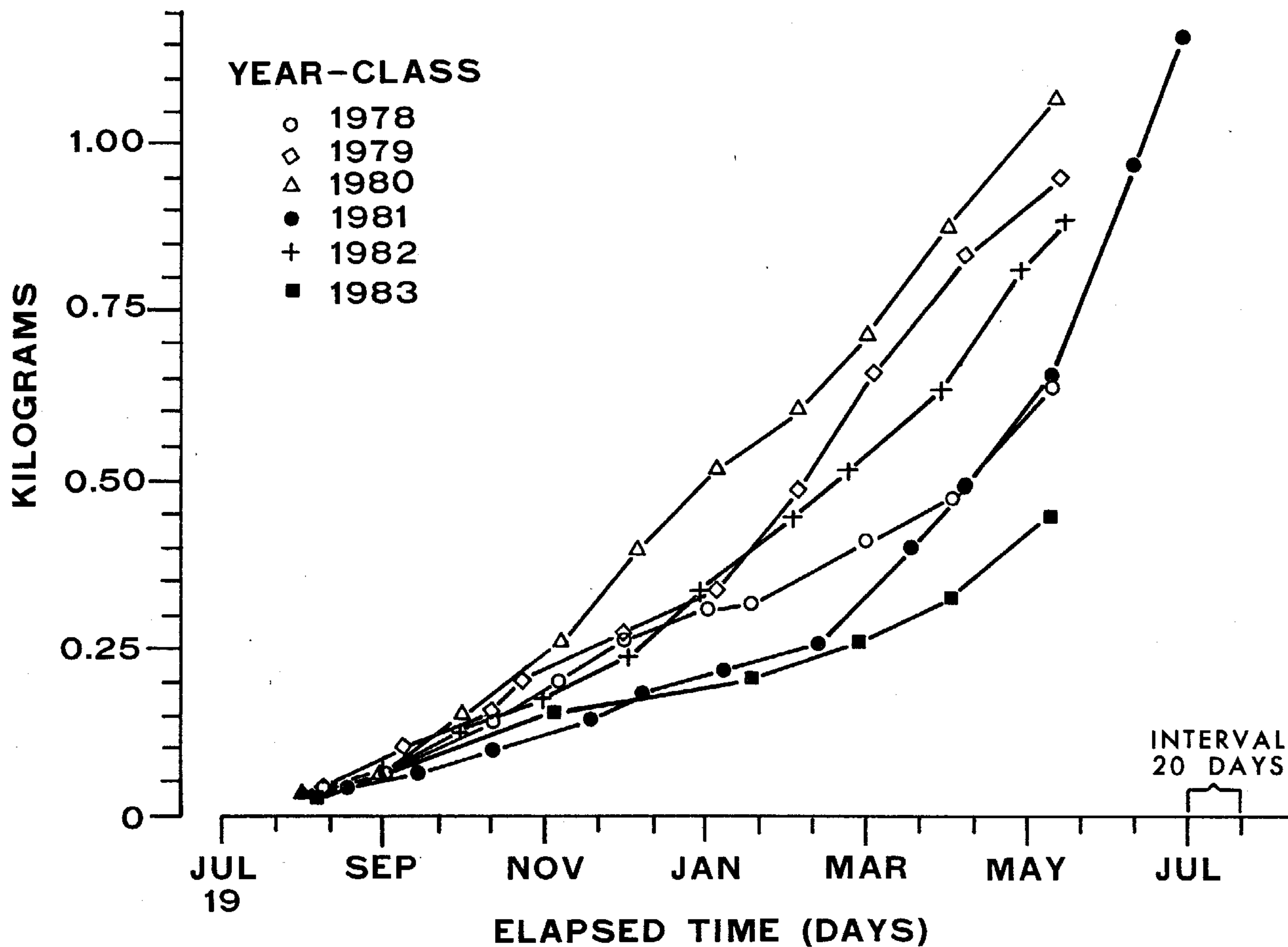


Figure 1. Average weight versus elapsed time for head started, Kemp's ridley sea turtles of the 1978-1983 year-classes.

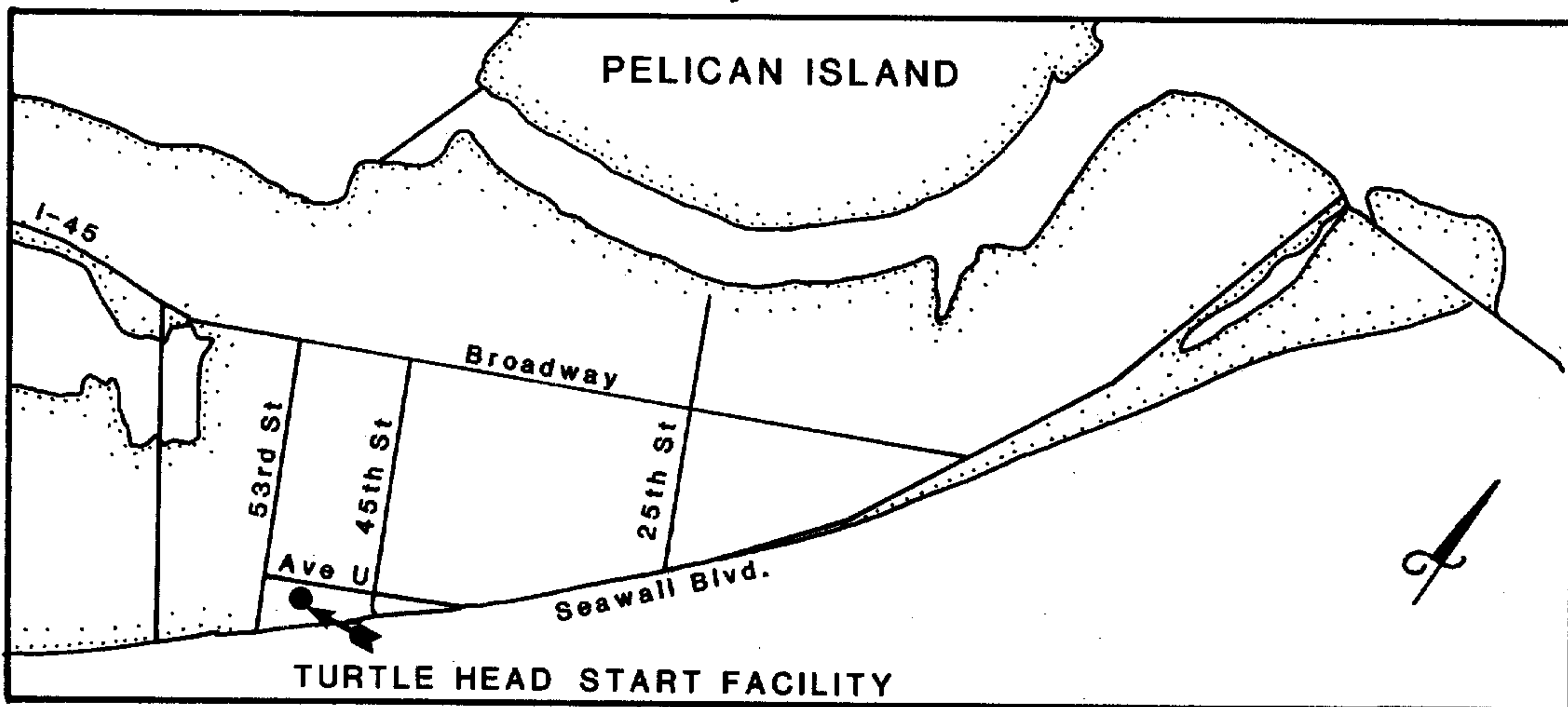
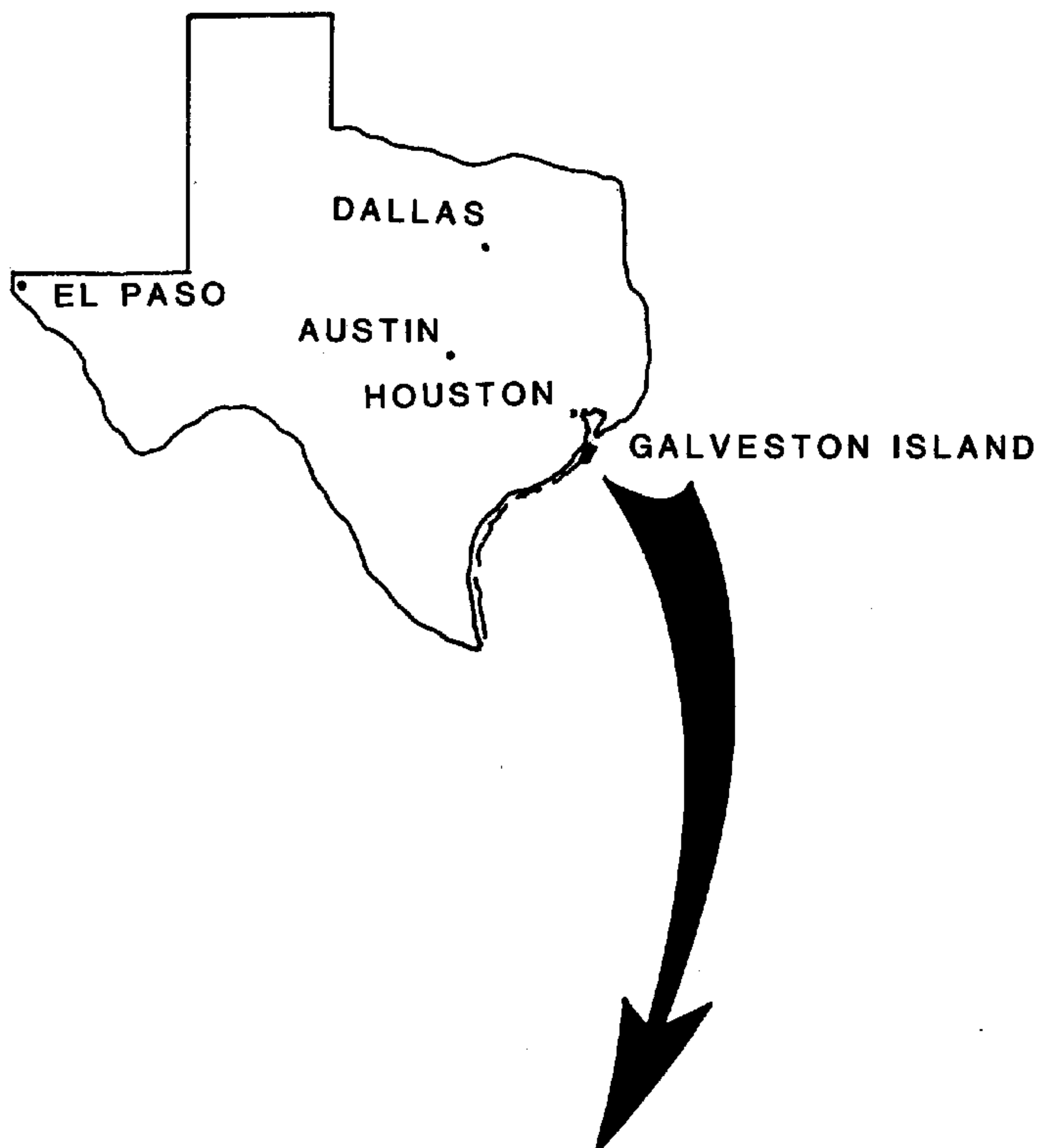


Figure 2. Location of the sea turtle head start research facilities (X) at the NMFS Galveston Laboratory.



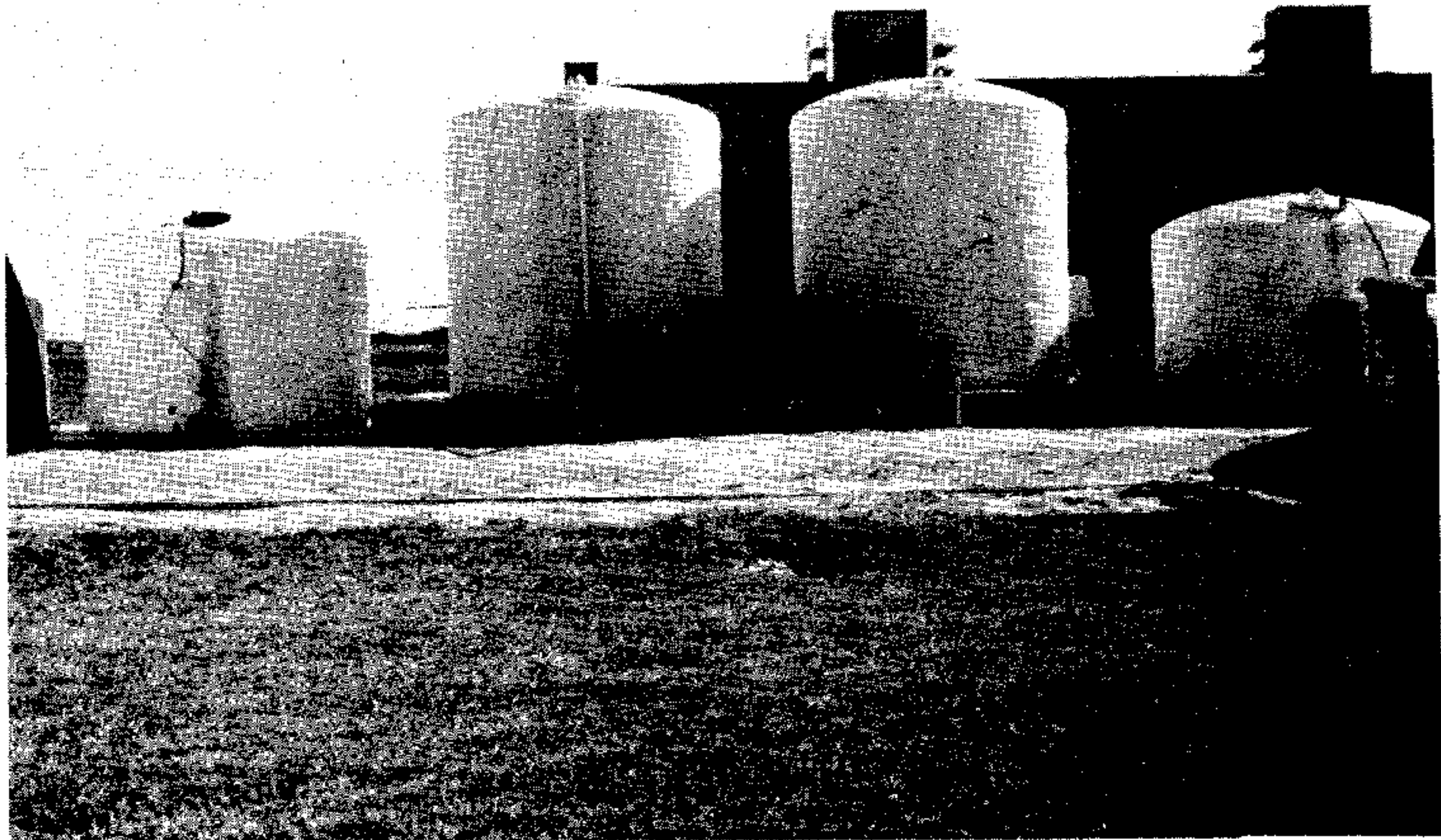


Figure 3. Insulated fiberglass seawater reservoirs supported by 6-in thick, steel-reinforced, concrete pads.



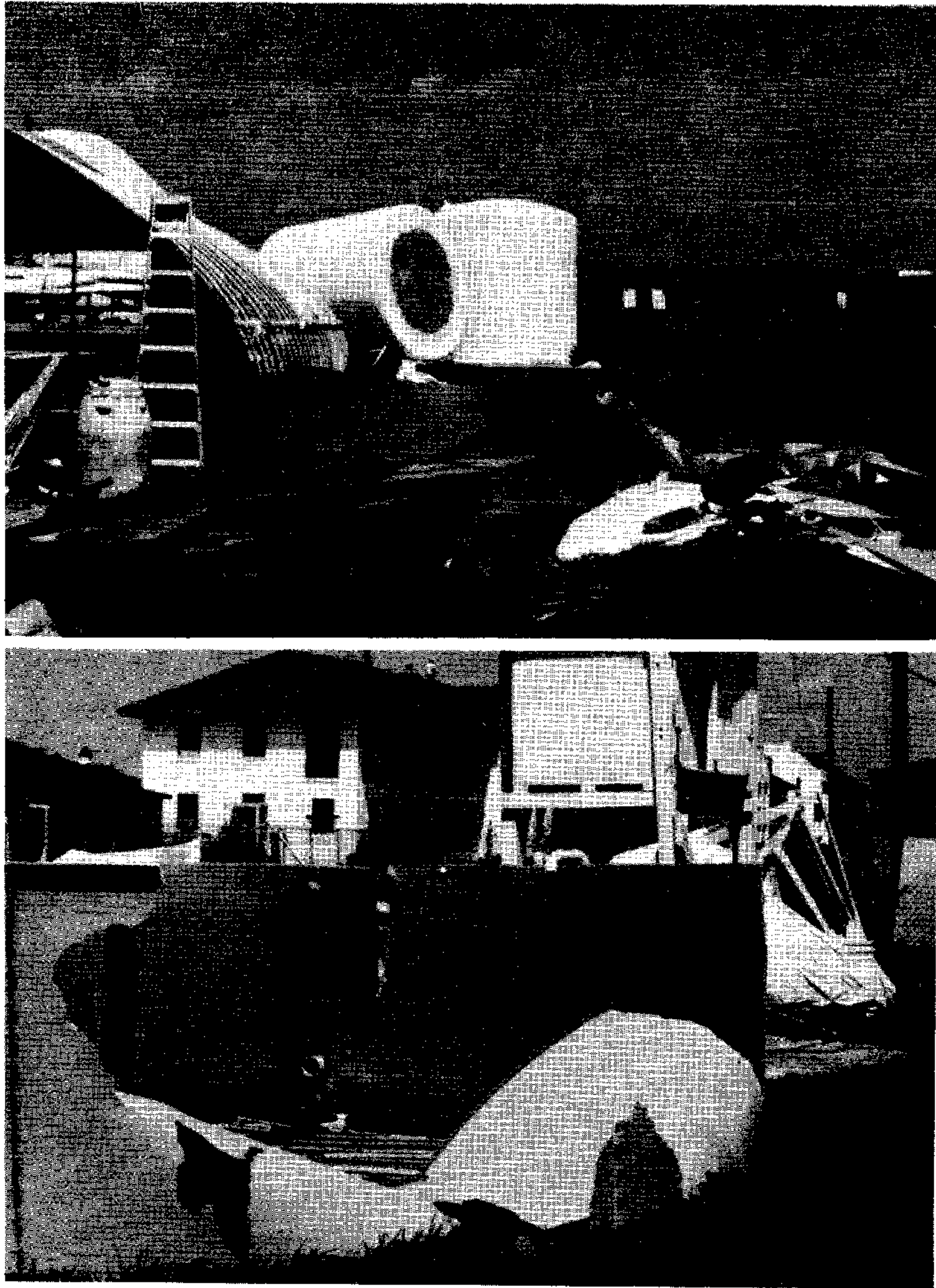


Figure 4. Damage by Hurricane Alicia to the sea turtle head start research facilities in August 1983.

A. Damage to facility, looking east; note upturned reservoir inside greenhouse frame structure.

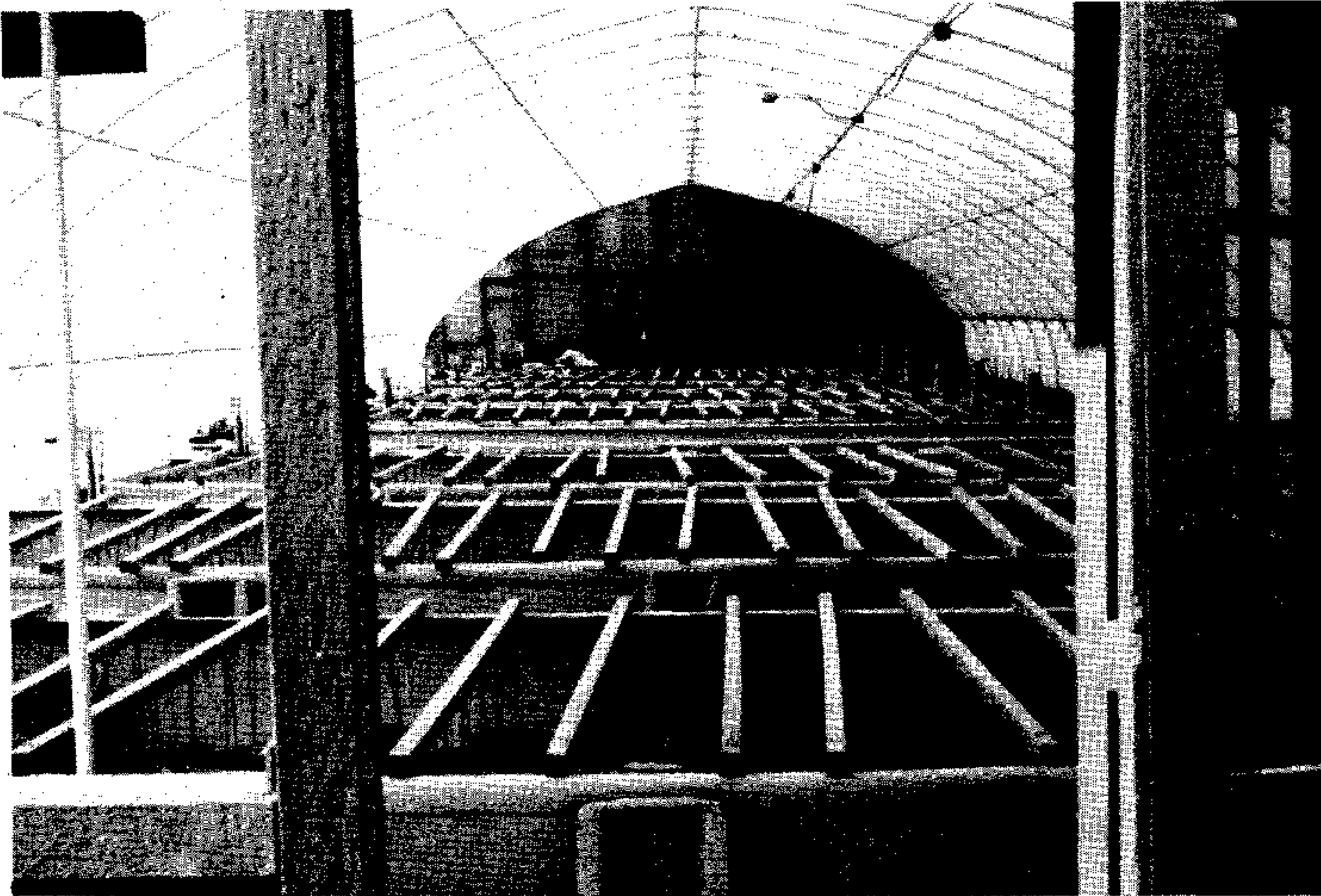
B. Damage to wastewater treatment area and west digestion tank; east digestion tank was totally destroyed.





Figure 5. Sea turtle head start research facilities after reconstruction following Hurricane Alicia in August 1983.





**Figure 6. Raceway system used in rearing the 1978-1983 year-classes of Kemp's ridley sea turtles.**



Figure 7. The raceway standpipe system that prevents overfilling of the raceways and allows quick drainage.





Figure 8. The bucket system used to isolate individual Kemp's ridley sea turtles to prevent aggressive attacks.





Figure 9. The standing basin unit (in background) consisting of 120 hemispherical basins.





Figure 10. The sick-bay (isolation and treatment) unit consisting of 86 hemispherical basins.



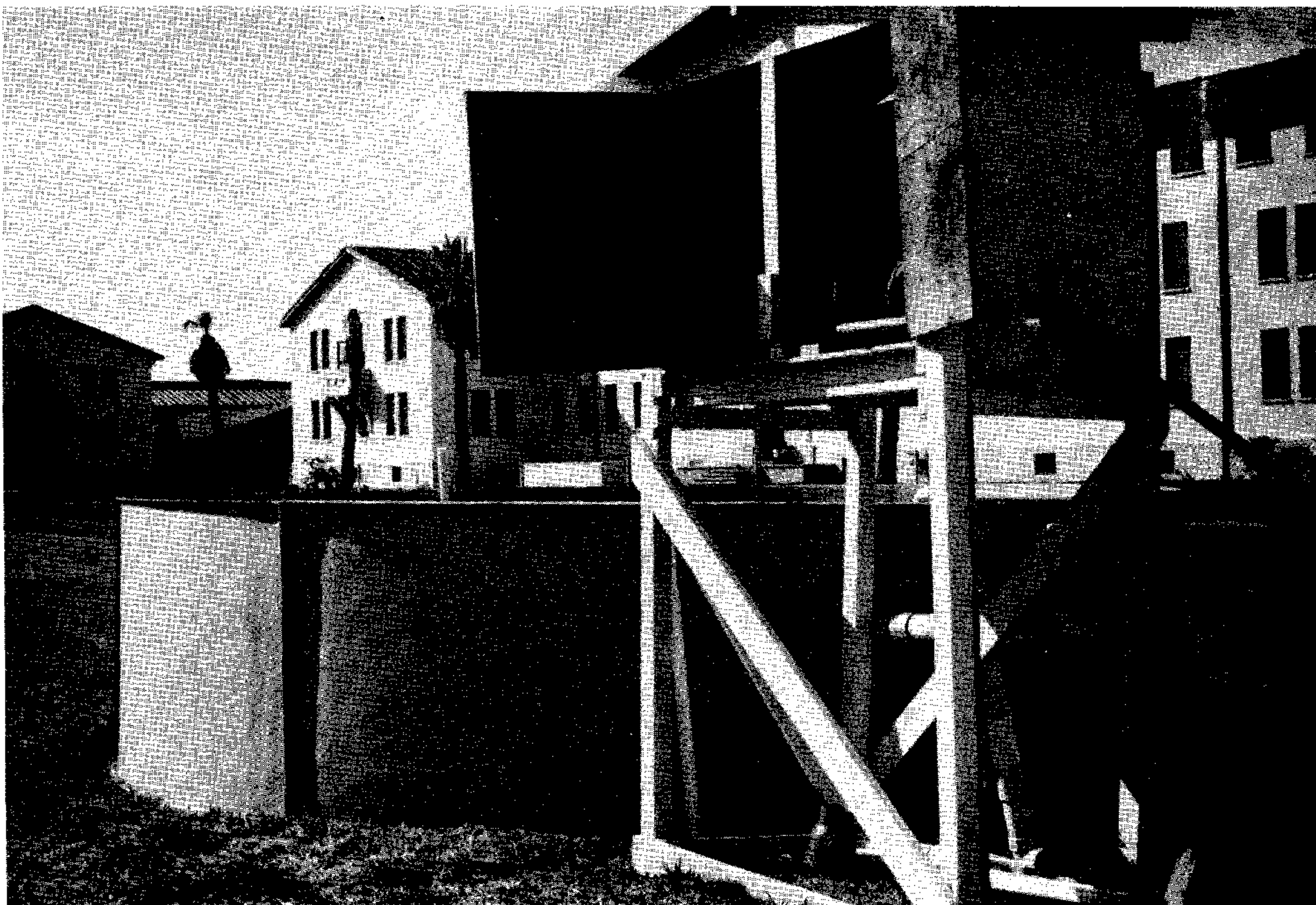


Figure 11. Fiberglass wastewater-digestion tank and air-blower house. The air-blower is elevated to prevent back-siphoning of wastewater into the blower.



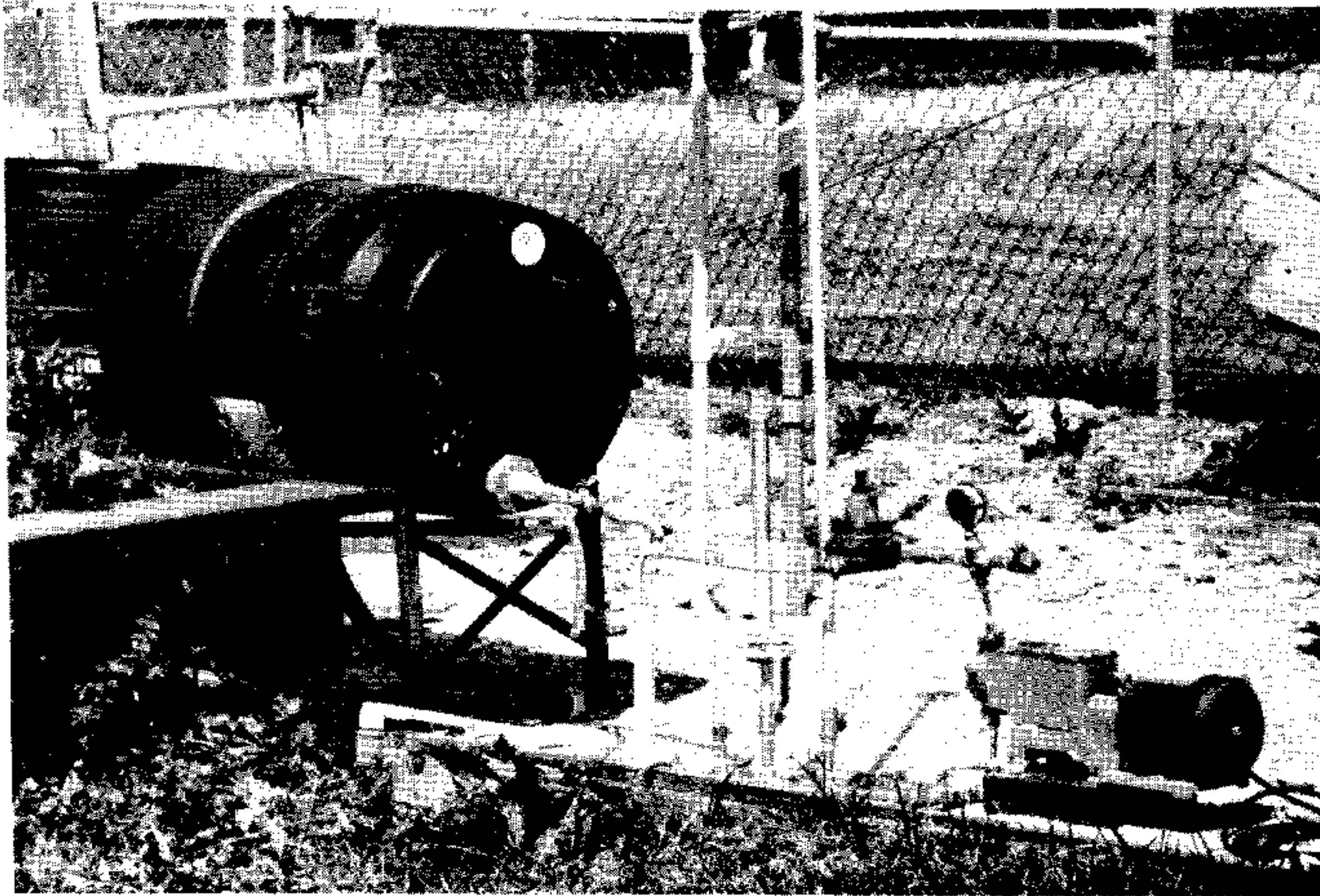
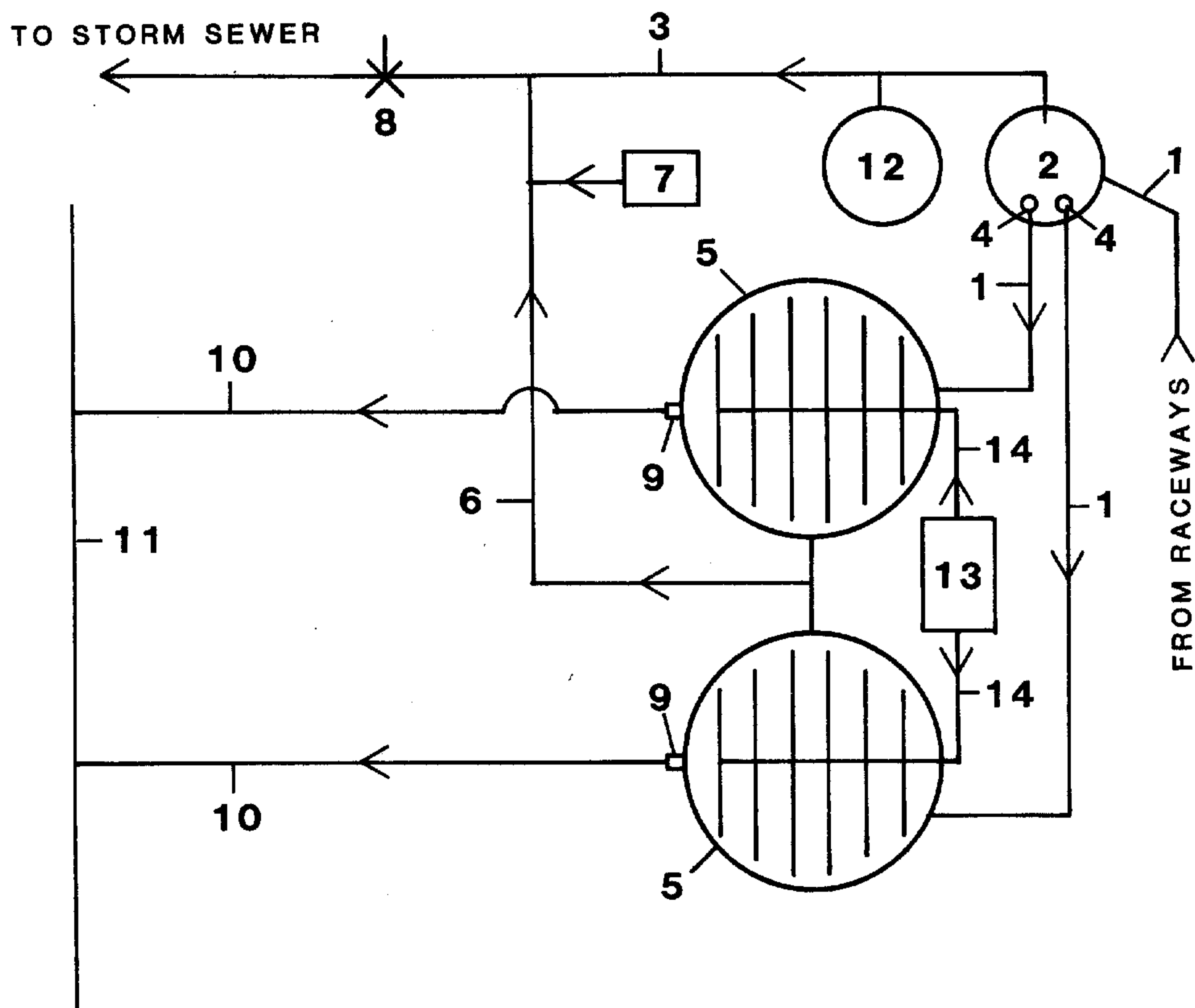


Figure 12. Hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) injector system.  $\text{H}_2\text{O}_2$  is injected into the wastewater effluent to achieve a concentration of 60-100 ppm in the effluent as it is being discharged.



Figure 13. Schematic diagram of tanks and plumbing used in the wastewater treatment system. (1) wastewater discharge pipe coming from raceway system; (2) in-ground sump pit; (3) sump-pit overflow discharge line; (4) sump-pit pumps; (5) sump-pit discharge lines; (6) aerated digestion tank no. 1; (7) aerated digestion tank no. 2; (8) treated wastewater discharge lines; (9) hydrogen peroxide injector; (10) wastewater discharge sampling tap; (11) discharge line to storm sewer; (12) bottom sludge drain; (13) bottom sludge drain; (14) sludge discharge line; (15) sludge discharge line; (16) domestic sewer line; (17) freshwater flush line; (18) air-blower house; (19) bottom air-blower pipe; (20) bottom air-blower pipe.



**1 DISCHARGE LINE**

**2 SUMP PIT**

**3 OVERFLOW LINE**

**4 PUMP**

**5 DIGESTION TANK**

**6 TREATED-WASTE  
WATER LINE**

**7 HYDROGEN PEROXIDE  
INJECTOR**

**8 SAMPLING TAP**

**9 BOTTOM SLUDGE DRAIN**

**10 SLUDGE DISCHARGE LINE**

**11 DOMESTIC SEWER LINE**

**12 FRESHWATER FLUSH TANK**

**13 AIR-BLOWER HOUSE**

**14 AIR-BLOWER LINE**

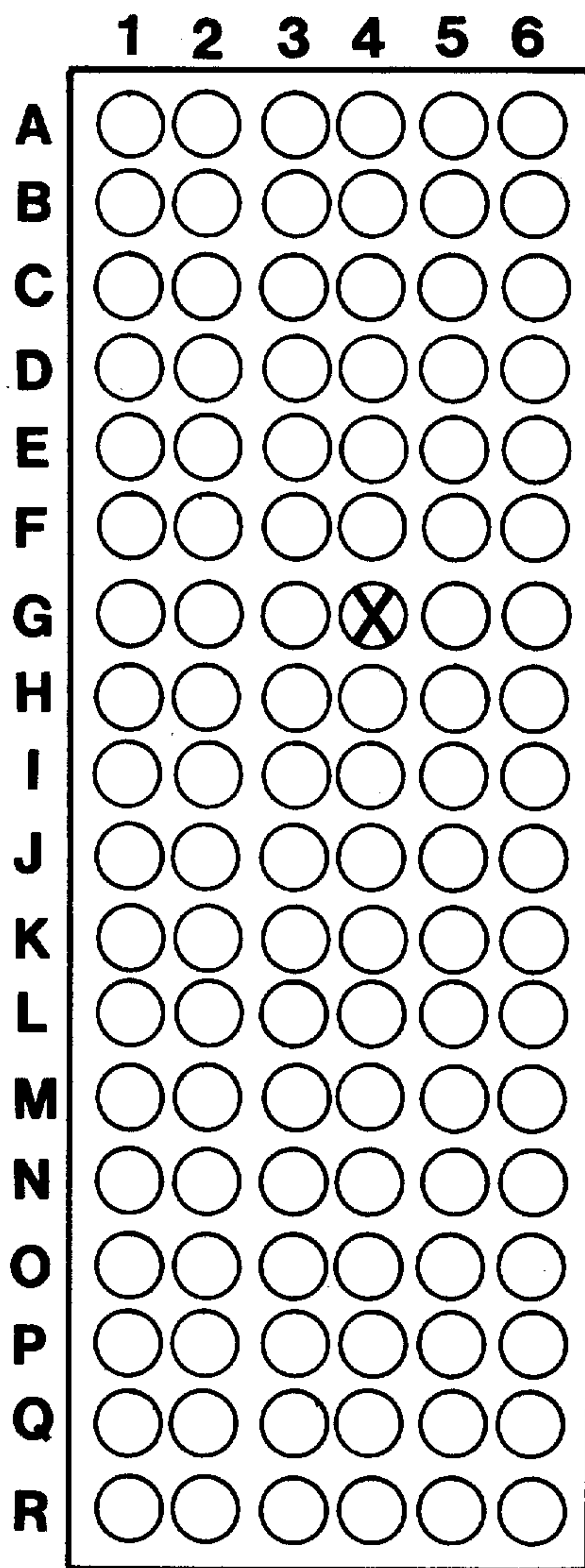


Figure 14. Bucket code scheme for eighteen rows (lettered A-R, from south to north) and six columns (numbered 1-6, from east to west) of buckets, for a total of 108 buckets per raceway. X marks bucket location G-4.



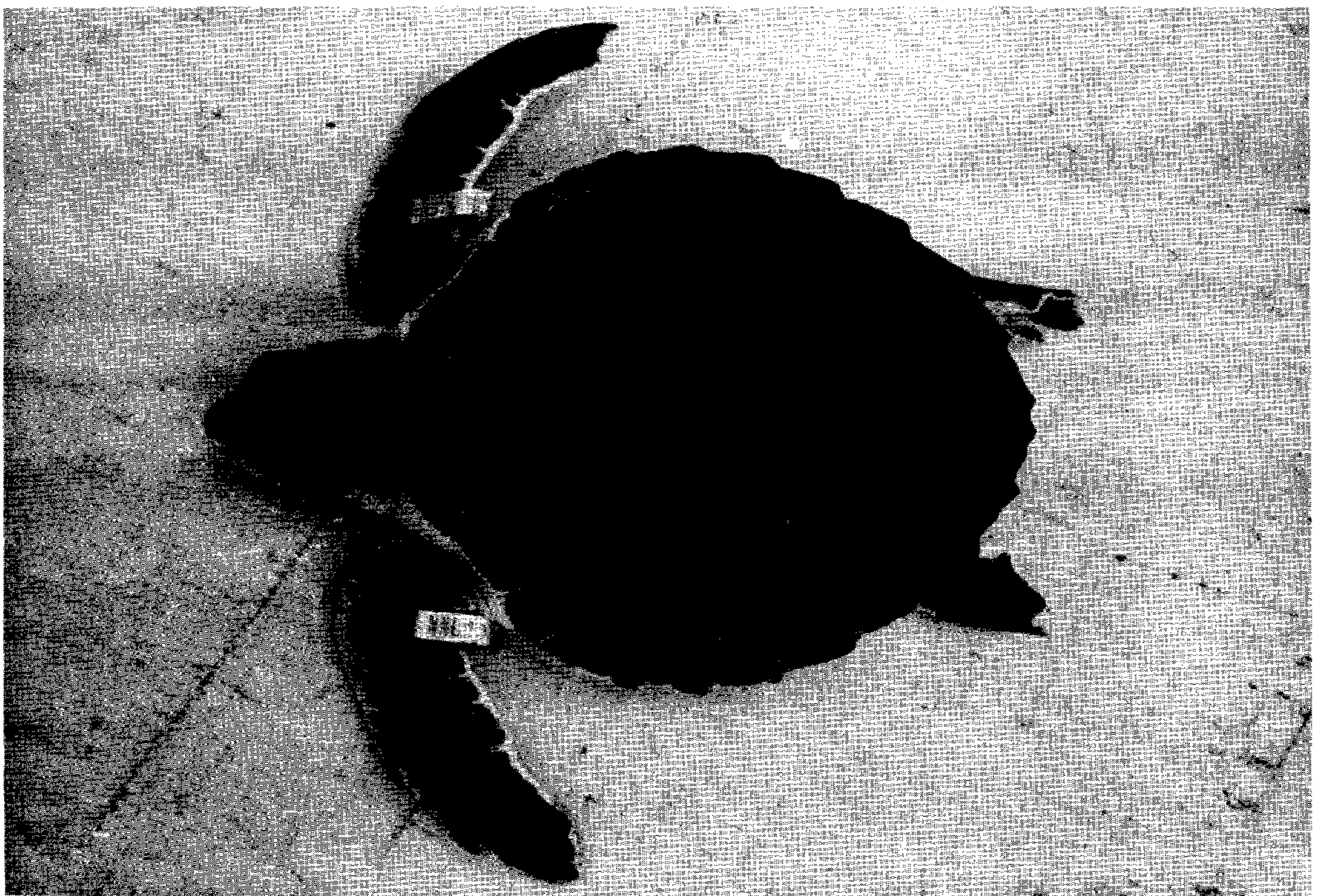


Figure 15. A double-tagged, Kemp's ridley sea turtle. Tags are monel metal, Hasco type, flipper tags.



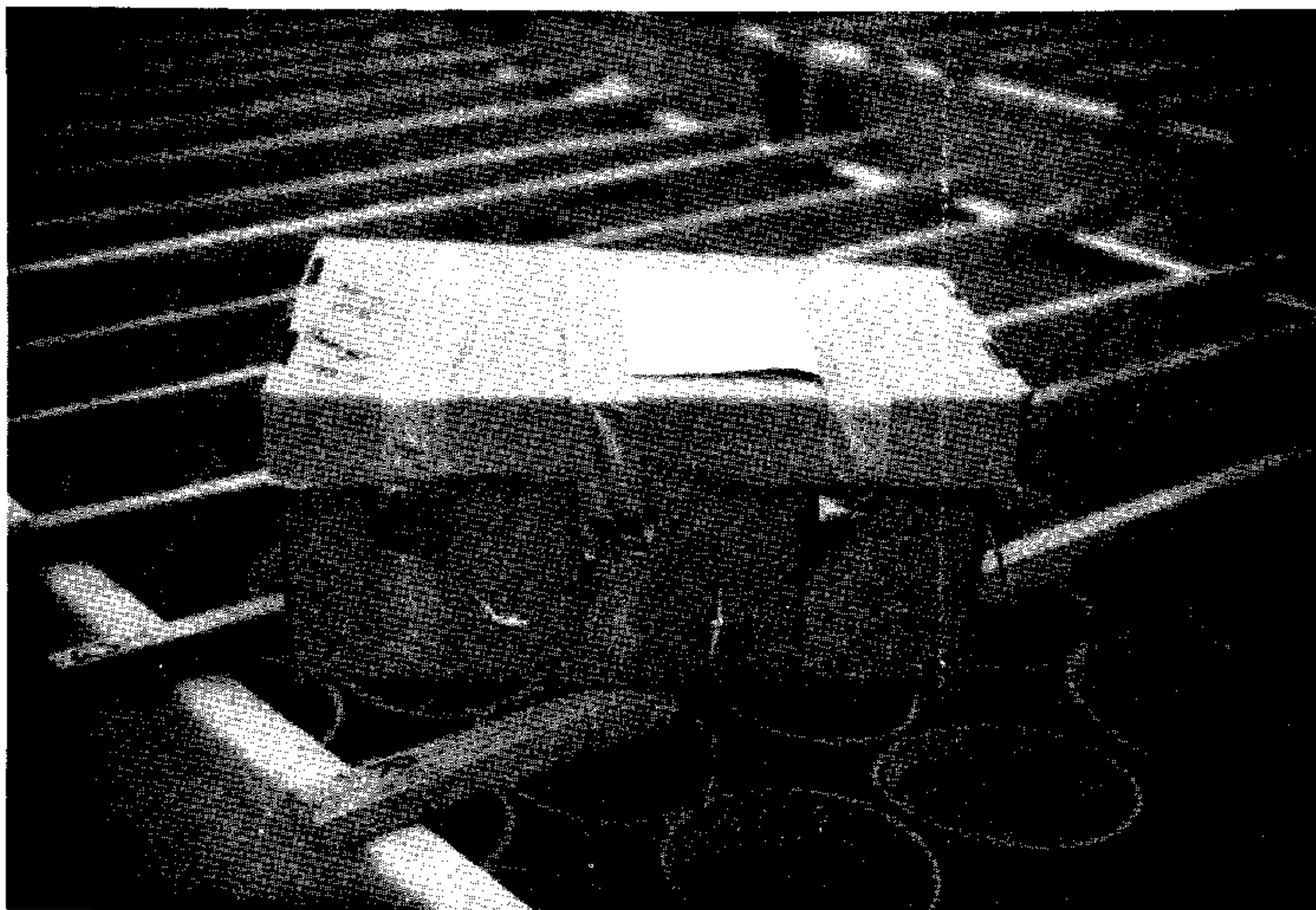


Figure 16. Transportation box for tagged Kemp's ridley sea turtles. Normally, eight tagged turtles (two horizontal layers of four each) are transported in this manner to the release site.

**PREFERENCE STUDY  
FOOD HOLDER**

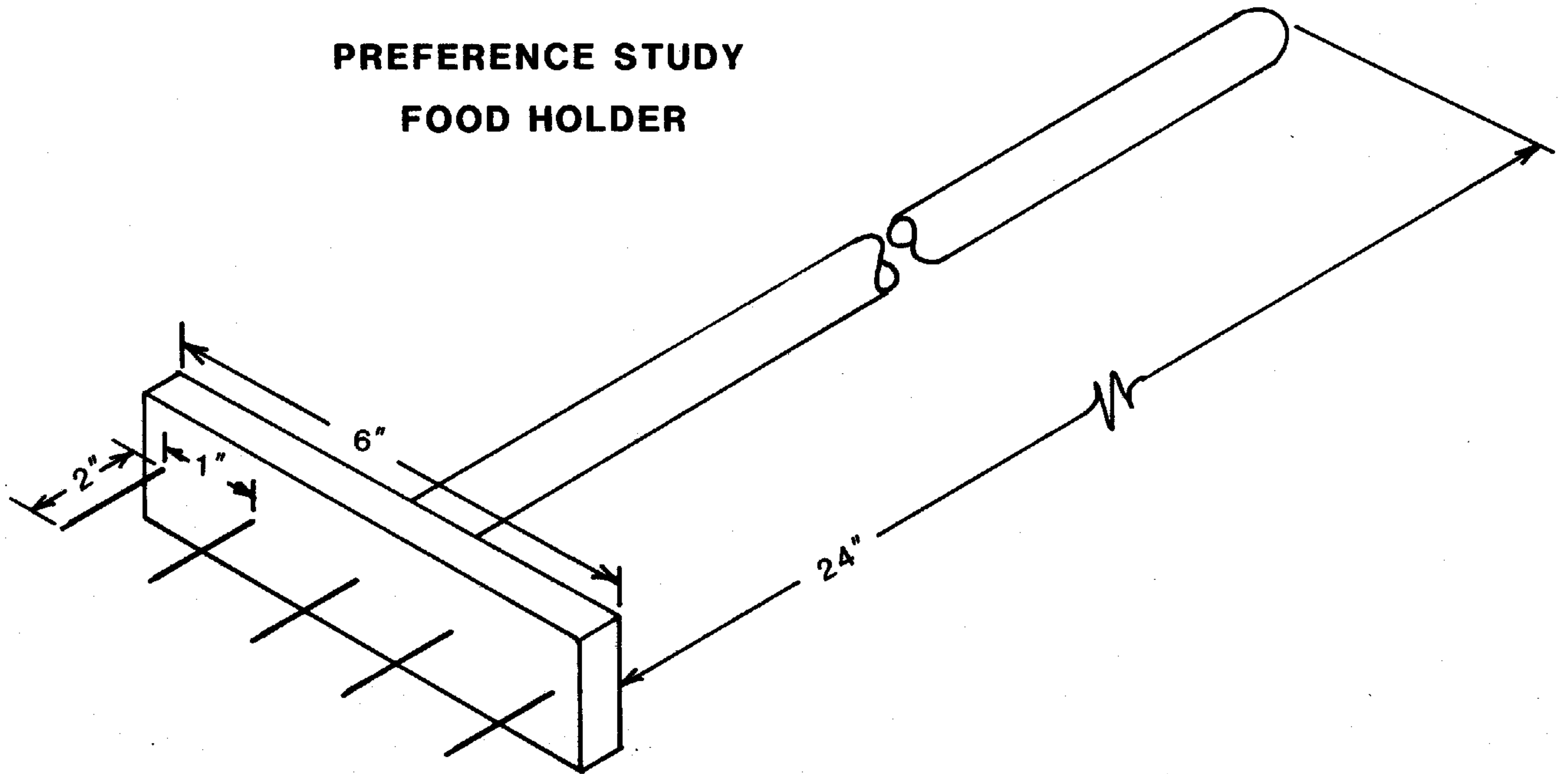


Figure 17. Food holder for food color preference study.



Figure 18. Average concentrations (ppm) of (Top) phosphate-phosphorus (in phosphorus equivalents;  $\text{PO}_4\text{-P}$ ) and (Bottom) ammonium-nitrogen (in nitrogen equivalents;  $\text{NH}_4\text{-N}$ ) in three raceways (1, 8, and 14) 48 hr after refilling (dashed line) and immediately after refilling with clean seawater (solid line).

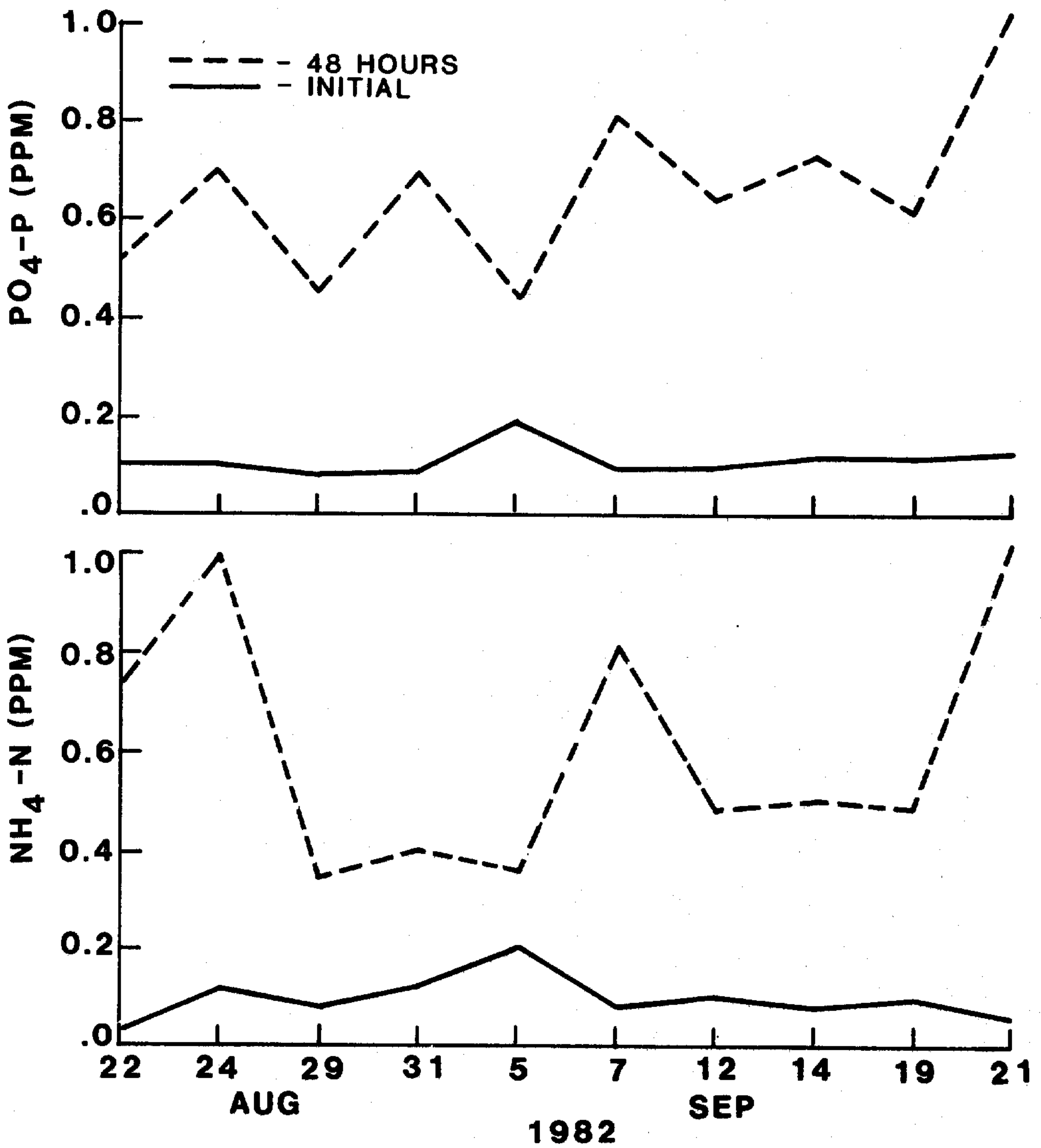
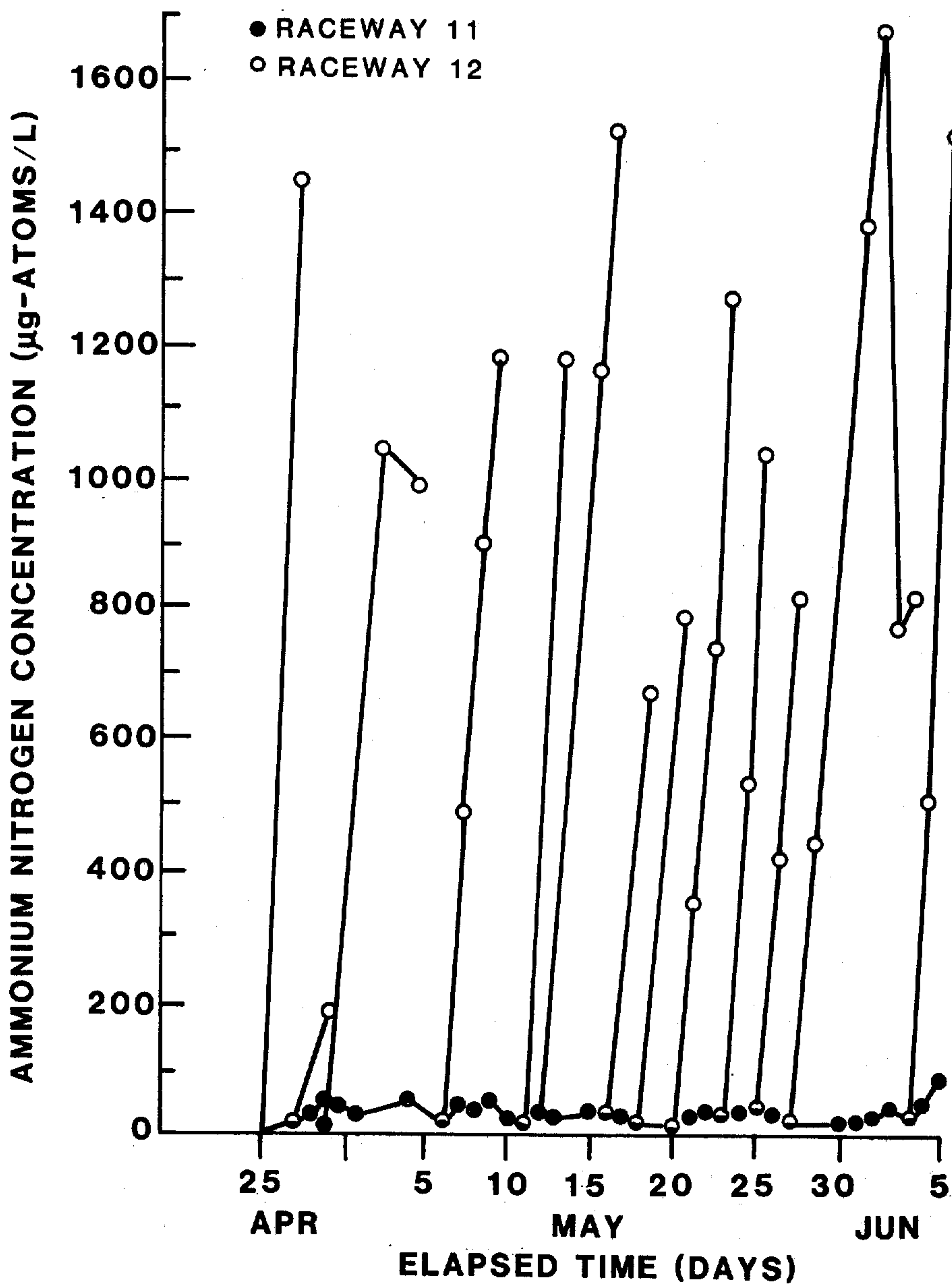


Figure 19. Concentration ( $\mu\text{g}$  atoms per liter) of ammonium nitrogen (in nitrogen equivalents;  $\text{NH}_4\text{-N}$ ) in a raceway containing Kemp's ridley sea turtles and seawater treated by a rotating, biological contactor (●) and in an untreated (control) raceway (○). The test raceway contained 102 Kemp's ridley sea turtles averaging 723 g in weight, and the control contained 108 averaging 740 g in weight.



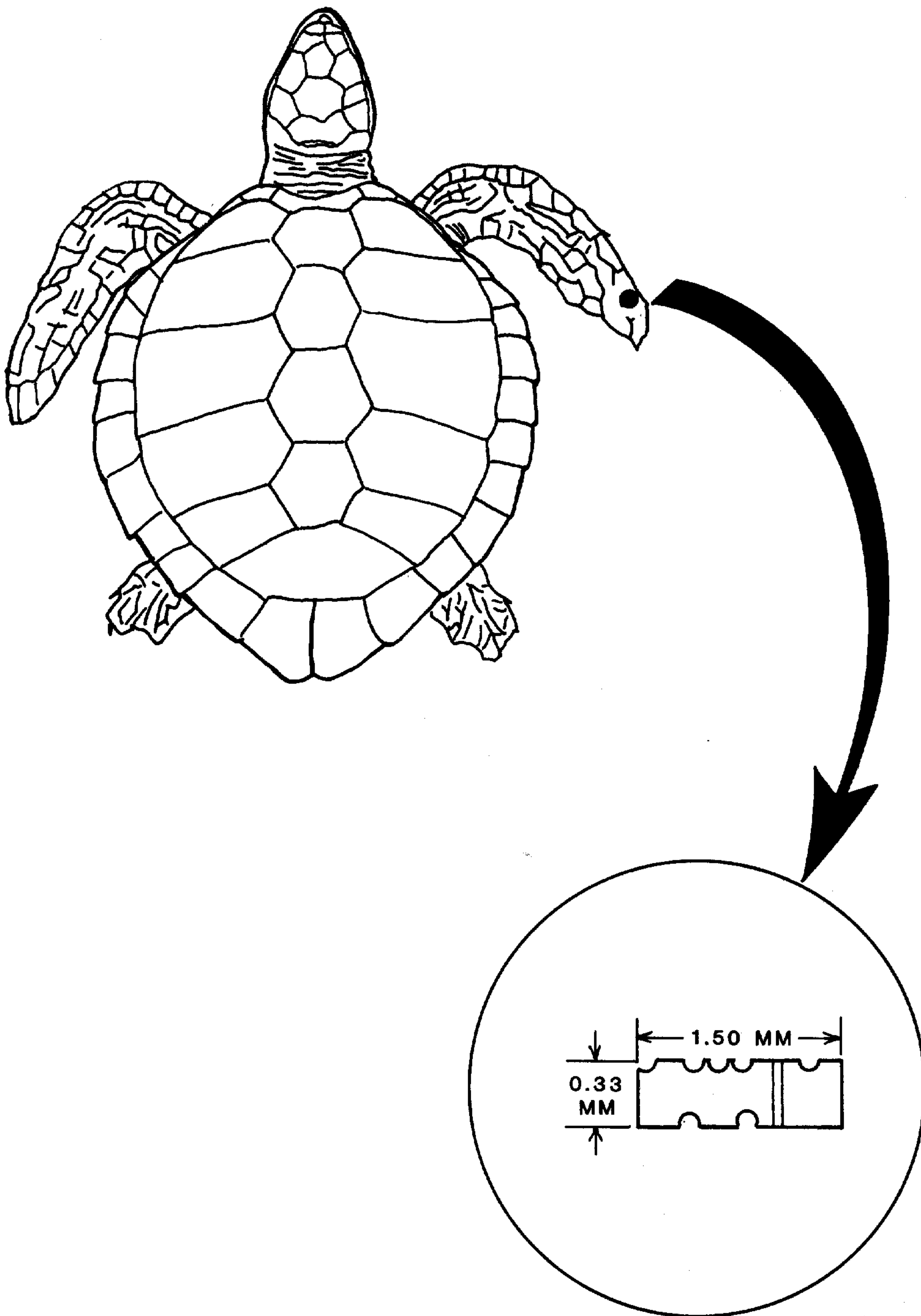


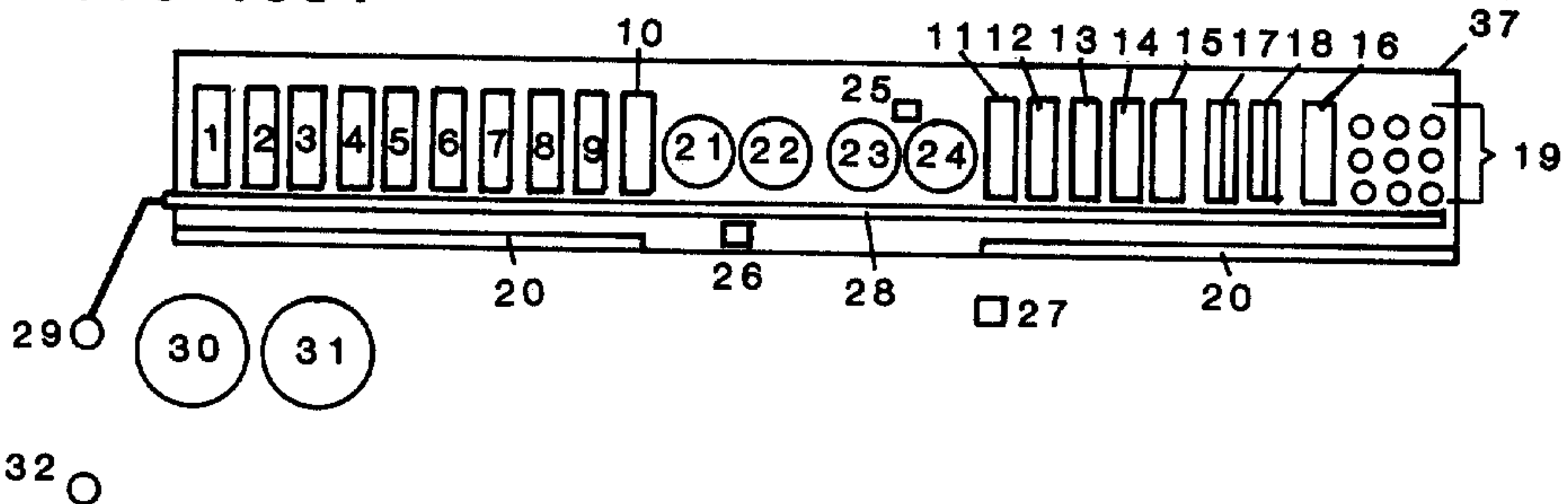
Figure 20. Diagram of location of implanted, binary-coded tag in the right front flipper of a head started Kemp's ridley sea turtle.

Figure 22. Sea turtle head start research facilities at the NMFS  
Galveston Laboratory: (A) 1978-1981; (B) 1981-1983; (C)  
1983-1984.

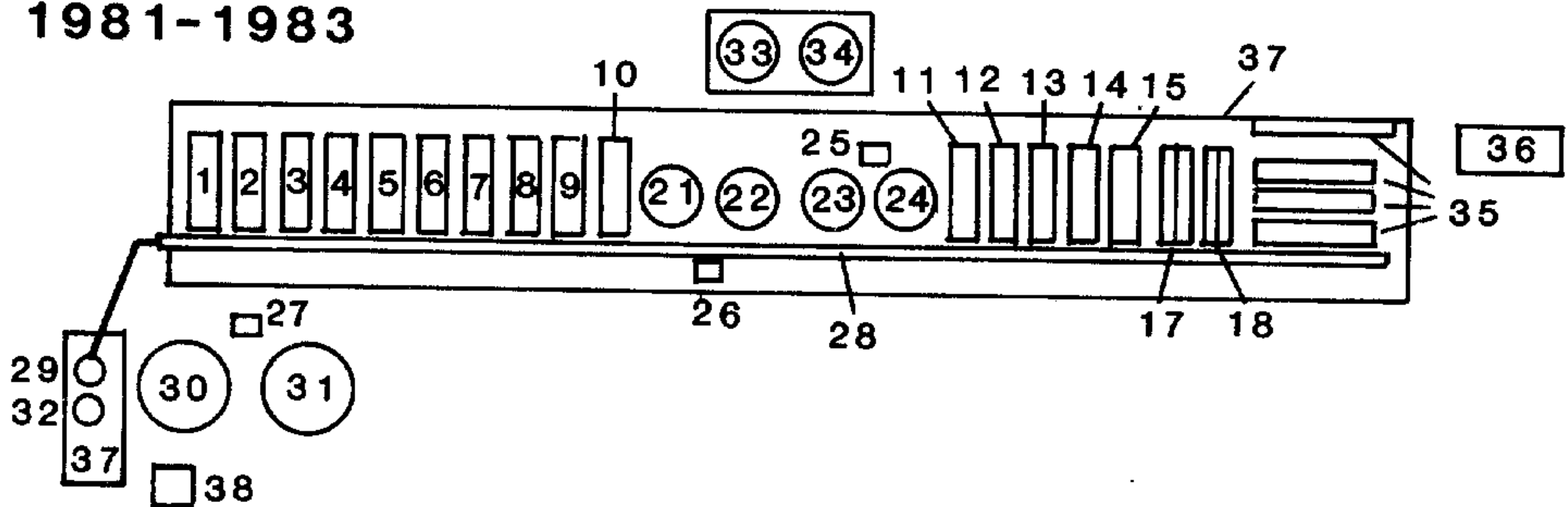


# SEA TURTLE HEAD START FACILITY

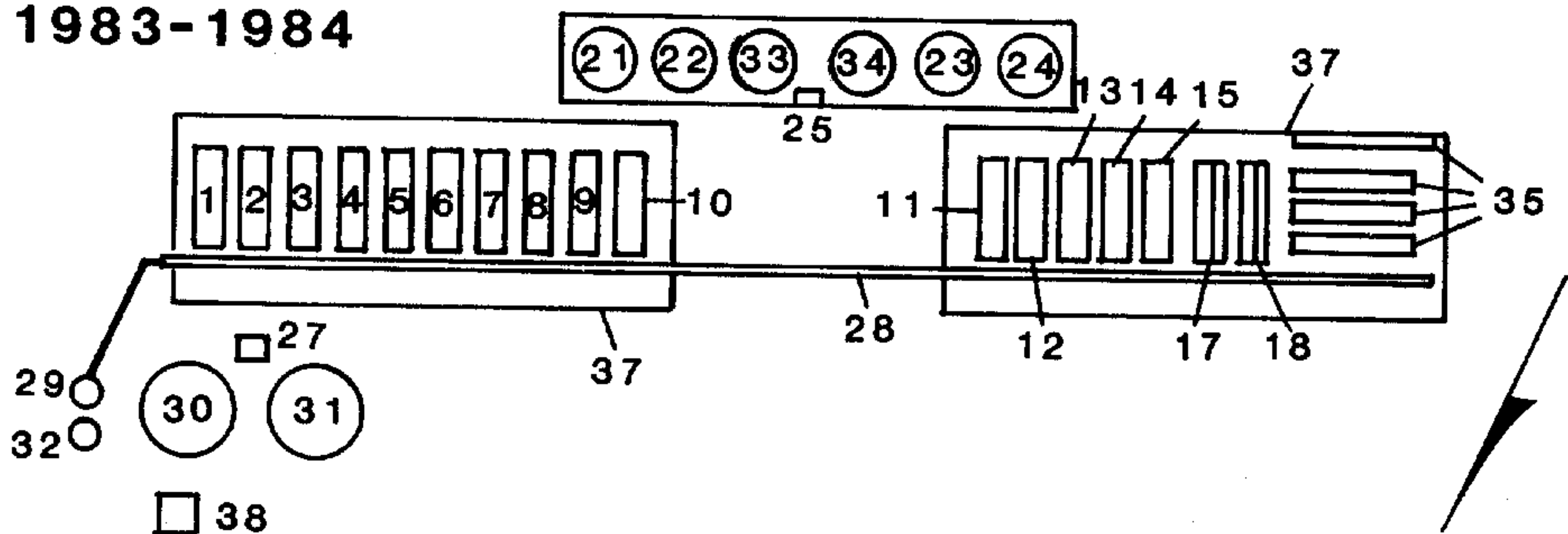
## A. 1978-1981



## B. 1981-1983



## C. 1983-1984



1-16 RACEWAYS

17-18 STANDING BASINS

19 6-FT DIA CIRCULAR TANKS

20 SIDE BASINS

21-24 7500-GAL RESERVOIRS

25-26 PUMPS

27 AIR BLOWER

28 DRAIN TROUGH

29 SUMP PIT

30-31 DIGESTION TANKS

32 FRESHWATER RINSE TANK

33-34 10,000-GAL RESERVOIRS

35 SICK BAY BASINS

36 TOOL HOUSE

37 QUONSET HUT

38 STORAGE

## APPENDICES

Appendix Table A1. Results of food color preference study on Kemp's ridley sea turtles: first trial from April 5-14, 1983. R = red, Y = yellow, B = blue, G = green and C = undyed (control).

Test Sequence	Turtle identi- fication number <sup>a/</sup>	First Choice				Second Choice			
		1	2	3	4	1	2	3	4
1	7-D-2	Y R	R R	Y B	R R	Y G	Y Y	R G	R R
2	7-D-6	R R	G R	R G	Y R	R R	G R	G Y	R R
3	7-E-4	G Y	Y G	C G	G B	R B	G G	B R	R B
4	7-K-2	R R	C R	R R	B R	R R	B R	R R	B R
5	7-L-4	R R	C Y	R R	R R	R C	C R	G R	R R
6	7-N-1	C R	R R	C Y	Y C	B Y	R B	R R	C G
7	7-P-4	R R	R R	B G	R Y	R R	R R	R C	B Y
8	7-P-6	R R	R G	B Y	R G	B R	C C	R B	B B
9	8-C-5	Y R	C C	G R	R R	Y R	Y R	Y C	B R
10	8-D-3	Y Y	R Y	B Y	R R	R R	C R	Y C	R R
11	13-C-1	R B	Y Y	B C	R R	R R	Y R	Y R	R R
12	13-C-5	R R	Y R	R B	R B	R R	Y R	R B	R R
13	13-C-6	B R	Y Y	Y Y	R R	R Y	C R	B Y	C R
14	13-D-4	Y R	B R	R Y	C R	Y Y	C R	Y Y	Y G
15	13-E-1	R R	C Y	R G	R C	R R	R R	R Y	Y G
16	13-F-3	R B	Y R	Y Y	Y G	R R	Y Y	Y Y	Y B
17	13-K-2	R R	C R	Y R	R R	R R	C R	Y R	R R
18	13-L-3	R Y	B R	R R	C B	R Y	C R	R R	C B
19	13-L-5	R R	C Y	R C	R R	R R	Y R	Y R	R B
20	13-M-6	R Y	G R	C R	R B	R R	G Y	R R	R R

<sup>a/</sup>Raceway no.-Row letter-Column number.

Appendix Table A2. Results of food color preference study on Kemp's ridley sea turtles: second trial from April 26 to May 5, 1983. R = red, Y = yellow, B = blue, G = green and C = undyed (control).

Test Sequence	Turtle identification number <sup>a/</sup>	First Choice				Second Choice			
		1	2	3	4	1	2	3	4
1	10-A-4	Y R	C Y	R R	B R	R R	R R	B B	Y Y
2	10-B-4	R G	B R	Y R	R R	Y Y	R R	R R	R G
3	10-C-1	Y R	B R	G R	R Y	R Y	Y Y	B B	R B
4	10-C-2	C C	B R	B B	R R	B C	Y C	R R	B R
5	10-C-5	C G	R Y	Y R	R G	C G	R G	R R	G B
6	10-E-4	B Y	R R	R G	R B	G R	Y B	B R	B G
7	10-E-6	Y R	B R	R Y	R R	C R	R Y	R R	B B
8	10-F-1	R R	G C	B G	R R	R R	R R	R R	B R
9	10-G-2	C R	R R	R R	Y G	C R	R R	B R	B G
10	10-G-3	R R	R R	R B	B G	R R	R R	B R	C R
11	3-J-2	Y R	R R	C R	R R	R R	R R	G G	R R
12	8-J-3	Y G	R C	Y R	B R	Y Y	R B	R B	Y R
13	8-J-6	Y R	R R	R R	B R	Y Y	R R	R C	R R
14	8-K-2	R C	R G	R R	R R	R R	R C	B R	R R
15	8-K-4	B R	R B	Y R	R R	R R	C R	Y B	R R
16	8-L-1	G R	C R	Y B	R R	R Y	R R	B G	R R
17	8-M-4	R R	C B	Y B	R R	Y R	Y B	B G	R R
18	8-O-2	G Y	Y C	G R	R R	R R	C R	B G	R R
19	8-P-1	R R	R R	R G	R R	R R	R Y	G Y	R R
20	8-P-6	G B	G G	R R	R R	R B	B R	B R	R R

<sup>a/</sup>Raceway no.-Row letter-Column number.



Appendix Table A3. Results of food color preference study on Kemp's ridley sea turtles: third trial from May 12-19, 1983. R = red, Y = yellow, B = blue, G = green and C = undyed (control).

Test Sequence	Turtle identification number <sup>a/</sup>	First Choice				Second Choice			
		1	2	3	4	1	2	3	4
1	13-N-5	R R	B B	C R	B R	R Y	R R	R R	G B
2	13-O-2	G R	R R	Y R	R Y	R R	G R	G R	R R
3	13-O-6	R Y	R R	R G	R R	R R	R B	R G	R R
4	13-Q-2	C R	R R	G R	R R	C R	G G	R R	R C
5	13-Q-6	C R	R R	Y R	R Y	G R	G R	B R	R R
6	13-R-1	R R	R R	R R	R R	R G	R B	R R	R C
7	14-A-3	Y Y	C C	R C	B C	Y R	G R	B R	R R
8	14-A-5	R R	R R	R R	R R	R B	R B	R R	B R
9	14-D-2	G Y	R R	R R	C C	R R	R C	R R	C R
10	14-F-2	R Y	R R	R R	Y Y	R R	B R	Y R	Y R
11	14-H-4	R R	R R	R C	C R	R B	R B	R C	C C
12	14-H-6	R C	B R	R B	C B	R G	R C	Y Y	Y Y
13	14-J-1	R Y	R Y	Y G	C Y	R R	B G	B G	C R
14	14-J-3	R B	R G	R C	R R	R R	B R	C R	B R
15	14-K-1	G G	R R	R G	R R	C R	B Y	R G	R B
16	14-K-5	R Y	R B	R G	R R	R R	C R	B Y	R R
17	14-L-1	R Y	R R	B R	R R	R B	C B	R R	R B
18	14-M-3	B R	R R	R C	R R	B B	C B	R C	R C
19	14-N-2	R R	R R	R C	R R	R B	R B	R C	C R
20	14-O-2	G R	R G	Y R	B R	B R	B B	R R	R R

<sup>a/</sup>Raceway no.-Row letter-Column number.

Appendix B. Procedures, reagents, and standards used for seawater chemistry analyses.

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A. Nitrate ( $\text{NO}_3\text{-N}$ )

Nitrate, the most completely oxidized state of nitrogen in water, is determined by the Brucine method (Jenkins and Medsker 1974). It involves the reaction of  $\text{NO}_3\text{-N}$  with brucine sulphate in strong (13N) sulfuric acid medium. Nitrite interference is eliminated by the addition of sulphanilic acid. Salinity interference is eliminated by increasing the salinity of all samples and standards to a level above which the effects of salinity are stable. Uneven heating, or, different temperature of samples produce erratic results. Therefore, all samples (and standards) must be treated identically.

Reagents

NaCl solution - a saturated solution.

Sulfuric acid - add 5 parts (v.)  $\text{H}_2\text{SO}_4$  to 1.25 parts (v.) distilled  $\text{H}_2\text{O}$ . Cool before using.

Brucine reagent - dissolve 1 g brucine sulphate and 0.1 g of sulphanilic acid in 70 ml of hot distilled  $\text{H}_2\text{O}$ . Add 3 ml concentrated HCl and make up to 100 ml with de-ionized water.

Procedures

1. Place 10 ml of sample in a test tube.
2. Place test tubes in a rack submerged in icewater, the depth of which should be sufficient to cover the portion of the test tubes containing the samples and reagents.
3. Add 2 ml of NaCl reagent to each sample and mix by swirling.
4. Carefully pour 10 ml  $\text{H}_2\text{SO}_4$  reagent into each sample. Incline each sample test tube for this addition.
5. Add 0.5 ml Brucine reagent to each sample.
6. Mix each sample by pouring back and forth one time in a mixing tube and replace in ice water.
7. Remove tubes from icewater and place in a boiling-water bath

for 20 min (a yellow color proportional to the concentration of  $\text{NO}_3\text{-N}$  in the sample develops during this time).

8. Stabilize color density by cooling samples in the icewater bath to approximately room temperature.
9. Determine sample optical density at 410 mμ in a spectrophotometer, or in a filter type electrophotometer using the latter's 425 (purple) filter.
10. Compare sample optical density to standard optical density to calculate concentration.

#### B. Nitrite $\text{NO}_2\text{-N}$

The procedure used is that of Shinn (1941) as applied to seawater by Bendschneider and Robinson (1952). The procedure is based on the reaction of nitrite in saltwater with sulphanilamide in an acid solution. The resulting diazo-compound reacts with N-(1-naphthyl)-ethylenediamine to form a highly colored (red) azo dye.

##### Reagents

Sulfanilimide solution - dissolve 5 g of sulfanilimide in a mixture of 50 ml of concentrated HCL acid and about 300 ml of distilled water.

N-(1-naphthyl)-ethylenediamine dihydrochloride solution - dissolve 0.5 g of the dihydrochloride in 500 ml of distilled water. Store in a brown bottle.

##### Procedures

1. Place 25 ml of sample in a 50 ml flask.
2. Add 0.5 ml of sulfanilimide reagent and mix.
3. After at least 2 min add 0.5 ml of ethylenediamine reagent and mix.
4. After no less than 10 min and no more than 120 min measure the optical density of the samples in a spectrophotometer at a wavelength of 543 mμ, or in a filter-type electrophotometer

equipped with a green 525 mu-filter.

5. Compare sample optical density to standard calibration curve to convert to concentration units.

### C. Ammonium-Nitrogen ( $\text{NH}_4\text{-N}$ )

We used the phenol-hypochlorite method of Solorzano (1969) as described by Strickland and Parsons (1972). The procedure involves treating samples in an alkaline citrate medium with sodium hypochlorite and phenol in the presence of sodium nitroferricyanide (nitroprusside) that acts as a catalyzer. The intensity of the blue indophenol that develops is an indication of the concentration of  $\text{NH}_4\text{-N}$  in the sample.

#### Reagents

Phenol solution - dissolve 20 g of crystalline reagent grade phenol in 200 ml of 95% v/v ethyl alcohol.

Sodium nitroferricyanide solution-dissolve 1.0 g of sodium ferricyanite in 200 ml of de-ionized water. Store in an amber bottle.

Alkaline reagent - dissolve 100 g of sodium citrate and 5 g of sodium hydroxide (analytical grade) in 500 ml of de-ionized water.

Sodium hypochlorite reagent - use Clorox.

Oxidizing solution - mix 100 ml of alkaline reagent and 25 ml of clorox. Keep this solution stoppered while not in use. Prepare fresh every day.

#### Procedures

1. Add 25 ml of sample to a 50 ml erlenmyer flask.
2. Add 1 ml of phenol reagent to each sample and mix.
3. Add 1 ml of sodium nitroferricyanide reagent to each sample and mix.
4. Add 2.5 ml of oxidizing reagent to each sample and mix.
5. Allow flasks to stand at room temperature for at least 1 hour



(color produced is stable for 24 hours).

6. Determine the optical density of the blue color in a spectrophotometer at 640 mμ, or in an electrophotometer with a red filter.
7. Compare sample optical density to standard calibration curve to convert to concentration units.

#### D. Phosphate-Phosphorus (PO<sub>4</sub>-P)

The procedure used to determine PO<sub>4</sub>-P in seawater is that of Murphy and Riley (1962). It is also included in Strickland and Parsons (1962). The procedure is based on the reaction of phosphate in seawater with a composite reagent containing molybdic acid, ascorbic acid, and trivalent antimony.

#### Reagents

Ammonium molybdate solution - dissolve 15 g of reagent grade ammonium molybdate [(NH<sub>4</sub>)<sub>6</sub> MO<sub>7</sub>O<sub>24</sub>·4H<sub>2</sub>O] in 500 ml of de-ionized water. Store in plastic bottle out of direct sunlight.

Sulfuric acid solution - add 150 ml concentrated reagent grade sulfuric acid to 900 ml of de-ionized water. Allow the solution to cool and store in a glass bottle.

Ascorbic acid solution - dissolve 27 g of reagent grade ascorbic acid in 500 ml of de-ionized water. Store (frozen solid) in a plastic bottle in a freezer. Thaw for use and refreeze at once.

Potassium antimonyl-tartrate solution - dissolve 0.34 g of potassium antimonyl-tartrate (tartar emetic) in 250 ml of de-ionized water. Store in a glass, or plastic bottle.

### Mixed reagent

Mix together 100 ml of the molybdate solution, 250 ml of the sulfuric acid solution, 100 ml of the ascorbic acid solution and 50 ml of the potassium antimonyl-tartrate solution.

Prepare this reagent for use daily and discard any excess. Do not store longer than 6 hours.

### Procedures

1. Add 25 ml of sample to a 50 ml Erlenmyer flask.
2. Add 2.5 ml of the mixed reagent.
3. Mix by swirling the flask.
4. After at least 5 minutes measure the optical density of the blue color in a suitable photometer, or at 750 mμ in a filter-type electrophotometer.
5. Compare sample optical density to standard calibration curve to convert to concentration units.

### E. Laboratory water for analyses

The de-ionized water used in our laboratory is prepared by passing tap water, that varies from 200 to 800 ppm total solids, through a mixed bed de-ionizer (which is supplied, and replaced as needed, by a private contractor). Our distilled water is prepared by distilling the de-ionized water with an all Pyrex still. Comparing blank values showed that distillation of the de-ionized water did not improve its quality as far as our chemical analyses were concerned. Therefore, whenever distilled water is suggested in the analytical procedures, de-ionized water may be used provided it is produced from a mixed bed de-ionizer of the type that removes virtually all of the positive and negative electrolytes.

F. Preparation of standards

Reagents used for preparing calibration standards must be readily soluble, reagent-grade chemicals, dried before use. To minimize contamination, a bottle of each is set aside for standardization purposes only. The following chemicals are used most frequently for calibration standardization at this laboratory:

1. Sodium nitrate ( $\text{NaNO}_3$ ) for  $\text{NO}_3\text{-N}$
2. Sodium nitrite ( $\text{NaNO}_2$ ) for  $\text{NO}_2\text{-N}$
3. Potassium acid phosphate ( $\text{KH}_2\text{PO}_4$ ) for  $\text{PO}_4\text{-P}$
4. Ammonium chloride ( $\text{NH}_4\text{Cl}$ ) for  $\text{NH}_4\text{-N}$

### Procedures:

1. Weigh a small amount of the desired chemical to the nearest mg. For convenience, the weight should be somewhere in the range of 0.1 g to 0.5 g.
2. Dissolve the weighed chemical into 1000x ml with de-ionized water, where x is numerically equal to the gram weight of the chemical. For example, if 0.235 g is the weight, it should be dissolved in 235 ml of water. When the chemical is completely dissolved and the solution thoroughly mixed (solution A), 1 ml will contain 1 mg of the chemical. Solution A is used to prepare the working standard from which calibration standards are prepared. Assume a series of NO<sub>2</sub>-N standards having a final volume of 25 ml are desired that will increase in increments of 1 u at NO<sub>2</sub>-N/l; i.e., 1 ml standard + 24 ml H<sub>2</sub>O = 1 ug at N/l; 2 ml standard + 23 ml H<sub>2</sub>O = 2 ug at N/l, etc. If solution A were used undiluted, 1 ml diluted to 25 ml would contain 580 ug at NO<sub>2</sub>-N/l. The working standard solution, therefore, is prepared by diluting 1 ml of solution A to 580 ml.

### Appendix B Literature Cited

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Solorzano, L. 1969. Determination of ammonia in natural waters by the phenolhypochlorite method. Limnol. and Oceanogr. 14:799.

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